

## Case Report

# Flexion tear-drop fracture of the axis without neurological deficits

S. Dohar A. L Tobing,<sup>1</sup> Putri Amalia Isdianto<sup>2</sup>

<sup>1,2</sup>Department of Orthopaedic and Traumatology, Faculty of Medicine, Universitas Indonesia,  
Cipto Mangunkusumo Hospital, Jakarta

## ABSTRACT

**Introduction :** Tear drop fracture is a cervical vertebral body fracture that has a triangular- or quadrilateral-shaped fragment that separates from antero-inferior corner and resembles a drop of water dripping from the entire vertebral body. This fracture mostly occurs at C5, C6, and C4 with common neurological injury. However, we found a rare case of C2-C3 tear drop fracture without neurological deficit. We tried to analyze the etiology and biomechanics of injury based on diagnostic images and biomechanical studies.

**Methods :** We reported a 40 year-old female with tear drop of C2 and C3 vertebrae. There were history of motorcycle accident, unconsciousness, neck pain and tenderness around her cervical neck. Radiological examination showed a tear drop fracture of the antero-inferior part of C2 vertebral body and fracture of C3. The patient underwent surgery for posterior stabilization using pedicle screws and rods in C2 and C3 vertebrae.

**Results:** Stable condition and normal neurological status were achieved after surgery and it remained excellent through the time. The patient was able to sit, stand, and walk after 3 days of surgery and was discharged from the hospital 5 days after surgery.

**Conclusion:** A rare tear drop fracture without neurological deficit in this case was considered to be the result of combination of flexion and axial-compressive injury. Due to its common instability problem following this pattern of injury, we decided to do a surgical procedure to this patient. Further evaluation on this patient gave a very good outcome.

## ABSTRAK

**Pendahuluan:** Fraktur tear drop adalah fraktur tulang vertebra yang memiliki fragmen berbentuk segitiga atau segi empat yang terpisah dari sudut antero-inferior korpus vertebra dan menyerupai gambaran tetesan air. Fraktur ini sering kali terjadi pada C5, C6, dan C4 dan disertai dengan cedera neurologis. Pada kasus ini, dilaporkan fraktur tear drop pada C2-C3 tanpa deficit neurologis yang jarang ditemui. Penulis mencoba menganalisis etiologi dan biomekanika cedera pada kasus ini berdasarkan gambaran diagnostik dan studi biomekanika.

**Metode:** Seorang wanita berusia 40 tahun dilaporkan mengalami fraktur tear drop pada C2 dan C3 vertebra. Terdapat riwayat kecelakaan sepeda motor, kehilangan kesadaran, dan nyeri pada leher dan pada pemeriksaan radiologi menunjukkan fraktur tear drop pada bagian antero-inferior dari tulang vertebra C2 dan C3. Pasien menjalani tindakan operasi untuk pemasangan instrumentasi posterior menggunakan pedicle screw dan rod pada vertebra C2 dan C3.

**Hasil:** Pasca-tindakan, kondisi klinis umum pasien stabil dan status neurologisnya juga normal. Pasien dapat duduk, berdiri, dan berjalan setelah 3 hari operasi dan keluar dari rumah sakit setelah 5 hari operasi.

**Kesimpulan:** Fraktur tear drop tanpa deficit neurologis dalam kasus ini jarang ditemui dan dapat disimpulkan sebagai akibat dari kombinasi gaya fleksi dan kompresi aksial. Oleh karena pola cedera seperti ini dinilai tidak stabil, diputuskan untuk melakukan prosedur pembedahan pada pasien ini. Evaluasi lebih lanjut pada pasien ini menunjukkan hasil yang sangat baik.

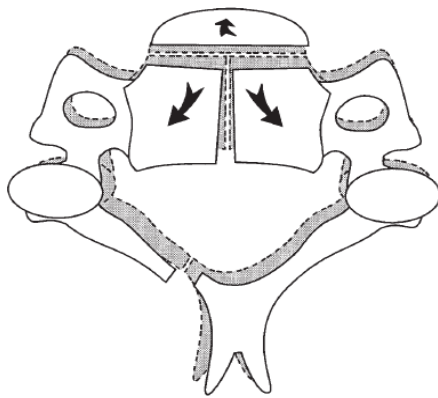
**Keywords:** Tear drop fracture, fracture of C2-C3 vertebrae, without neurological deficit, acute flexion injury, axial-compressive injury, cervical posterior stabilization.

**Corresponding author :** Putri Amalia Isdianto, putri.isdianto@gmail.com

## INTRODUCTION

Tear drop fracture is the most severe and unstable injury of the cervical spine. In most cases, patient is clinically presented with quadriplegia or even death.<sup>1,2,3</sup> It represents up to 15% of all cervical spine injuries.<sup>3</sup>

Flexion teardrop fracture of the cervical spine was first described by Schneider and Kahn in 1956 as a body fracture following an acute flexion injury with a wedge separation of antero-inferior aspect of the vertebral body.<sup>3</sup> Furthermore, it was defined as a fracture on the cervical vertebral body that has a triangular or quadrilateral shaped fragment that separates from the antero-inferior corner and resembles a drop of water dripping from the entire vertebral body (Figure 1).<sup>1,4</sup>



**Figure 1.** Illustration of flexion tear-drop fracture pattern and displacement (superior view).<sup>3</sup>

Most of the time, the posterior fragment of vertebral body is displaced backward into the spinal canal. Other characteristic of this injury is complete disruption of both anterior and posterior ligamentous structures, resulting in instability.<sup>4</sup>

The fractured vertebral body is separated into two parts by a usual sagittal plane fracture, but remains continuous through the pedicle and anterior arch of the vertebral foramen with lateral mass and articular process. Each fragment has a variable amount of posterior displacement resulting in protrusion of the posterior wall of the vertebral body into the spinal canal and variable compression of the spinal cord. It may also be slightly rotated, with some posterior opening of the sagittal fracture line.<sup>3</sup>

This kind of fracture mostly occurs at C5, C6, and C4.<sup>1,5</sup> The biomechanical of trauma occurs as the cervical spine sustains excessive compression force causing fractures

due to abrupt deceleration of the head and oncoming momentum of the torso mass.<sup>1</sup> In upper cervical spine, the axis (C2) is commonly fractured with an incidence around 3% of cervical spine trauma.<sup>6</sup>

Common neurologic injury accompanying this kind of fracture is the anterior cord syndrome, which consists of tetraplegia with loss of pain, temperature, and touch sensations. The posterior column, which consists of senses of position, motion, and vibration, is usually well preserved. In some cases, the neurological status can be incompletely impaired or even intact. Radiographic diagnosis of this case is very important for treatment purposes.<sup>4</sup>

Plain radiograph is the primary investigation that can give information about pre-vertebral soft tissue swelling and fracture fragments. CT-scan is the ideal investigation for demonstrating sagittal fracture involving the vertebral body and posterior elements. MRI will help to evaluate the extent of the soft tissue and the associated spinal cord injuries.<sup>6</sup>

In radiographic examination, some of these characteristics may be found:

- Forward displacement of an anterior fracture fragment of the vertebral body. The anterior aspect of the anterior fragment is generally aligned with the vertebral body below. In some cases, we can find it displaced and anteriorly rotated beyond the anterior vertebral body line.
- In almost all cases, posterior-inferior aspect of the posterior fragment is displaced backward in relation to superior aspect of the vertebral body below. The superior aspect of the posterior fragment is in normal alignment with inferior aspect of the vertebral body above. Midsagittal fracture of the posterior vertebral body fragment with retropulsion can cause spinal cord compression resulting in neurological disturbances.
- Widening of the interlaminar spaces, interspinous spaces, and facet joints. The facet joint between the level of injury and the one below is widened. We can find some varying degree of posterior displacement of the inferior facet in relation to the superior facet below.
- Complete disruption of the anterior and the posterior ligamentous structures at the intervertebral level inferior to the affected vertebrae.

- The disk space between the anterior fragment and the vertebral body below is usually maintained.<sup>1,4</sup>

Flexion tear-drop fractures can be classified into four types, which is based on the size of the anterior inferior fragment and displacement of the posterior part of the vertebral body into spinal canal.

Type 1: rupture of posterior ligament and small fracture (<3 mm) on the anterior inferior angle of the vertebral body. No sagittal fracture at the posterior body. Retrolisthesis was seen.

- Type 2: coronal fracture of the anterior inferior angle of the vertebral body, no retrolisthesis and there was sagittal fracture of the posterior body.
- Type 3: two subtypes, a and b, based on the vertebral body or retrolisthesis of its fragments.
  - o Type 3a : displacement < 4 mm
  - o Type 3b : displacement > 4 mm
- Type 4: represents anterior inferior angle of the vertebral body associated with the posterior facet dislocation and the anterior dislocation of vertebrae above.<sup>2</sup>

This study's purpose was to report a case of a female with flexion teardrop fracture of C2 vertebrae and fracture of C3 vertebrae after motor-vehicle accident without any neurological deficit. We tried to analyze the etiology and the biomechanics of the injury based on the diagnostic images and biomechanical studies.

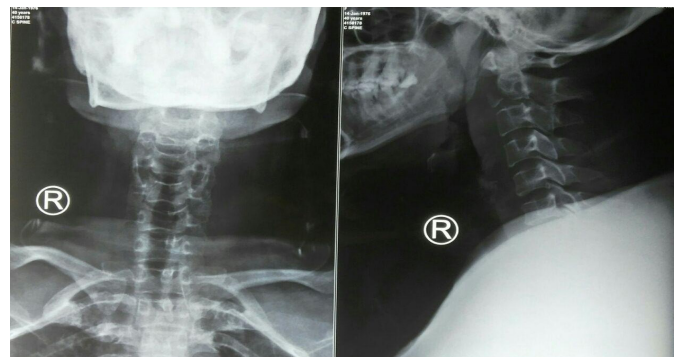
## METHODS

We reported a 40 year-old female who was admitted in the emergency room (ER) with previous history of motorcycle accident 2 days prior admission. The patient was riding a motorcycle and wore a helmet with medium speed when suddenly she slipped and fell down. She was reportedly unconscious immediately after the accident and did not remember the exact mechanism of the injury. She complained on the pain around the neck and both arms and legs. Her extremities were bruised but there were no other injuries. No neurological deficit was found either.

From physical examination, the patient was generally on stable condition. She was conscious and alert. Glasgow coma scale (GCS) was at the best eye opening (E4), best verbal response (V5), and best motor response (M6),

pupils were equal and reacting to light. She wore a hard-collar-brace to stabilize the cervical spine. There was no abnormality found on her secondary survey. There was no bruise, wound or marked deformity on her cervical area. She felt tenderness around her cervical with visual analogue score (VAS) of 2-3. Her neurological status was intact. Motor function of both upper and lower extremities were all 5 in score. Sensory function remained undisturbed in all levels. There was no hyperreflex signs of normal reflexes and there was no pathological reflexes. There was no history of urinary or fecal incontinence.

Lateral projection of cervical plain radiograph showed that there was a tear drop fracture of antero-inferior part of the C2 vertebral body (Figure 2). There was also posterior displacement of the posterior C2 vertebral body. The C2-C3's facet joint and interspinous process distance were slightly widened. There was no marked deformity or widening of interpedicular distance from AP projection.



**Figure 2.** Cervical plain radiograph in AP (left-side) and lateral (right-side) projections showed there was a flexion tear-drop fracture of the axis (C2).

CT-scan of cervical revealed that there was a tear-drop fracture of the C2 vertebrae and also a fracture in the left vertebral body of the C3 vertebrae (Figure 3, 4, and 5). There was no evidence of cervical canal encroachment. Vertebral body height of C2 and C3 were considered normal.

Non-contrast cervical MRI showed some cervical canal compromised behind the C2 level. C2-C3 disc space was also slightly narrowed without any disc protrusion. There was no disruption within the anterior and posterior longitudinal ligaments, the flavum ligament, the interspinous and the supraspinous ligaments (Figure 6 and 7).

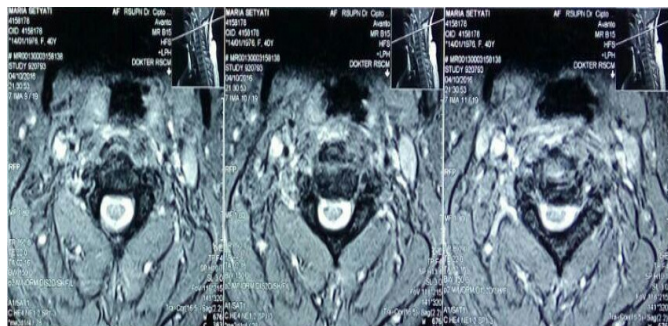




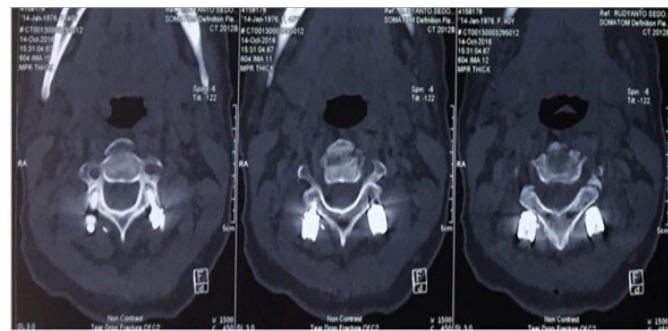
**Figure 3.** Cervical CT-scan of C2 vertebrae in axial plane showed there was a fracture on the anterior part of C2 vertebral body. The anterior fragment was avulsed and displaced anteriorly.



**Figure 5.** Cervical CT-scan in sagittal plane showed the flexion tear drop appearance of C2 vertebrae.



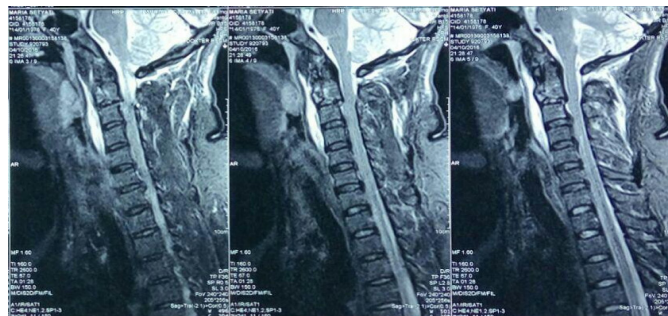
**Figure 7.** T2-weighted image of non-contrast cervical MRI in axial plane, in C2-C3 vertebrae level.



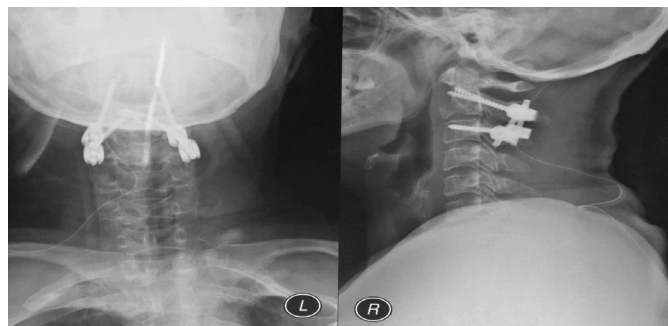
**Figure 9.** Post-operative cervical CT-scan in axial plane of C2 vertebrae.



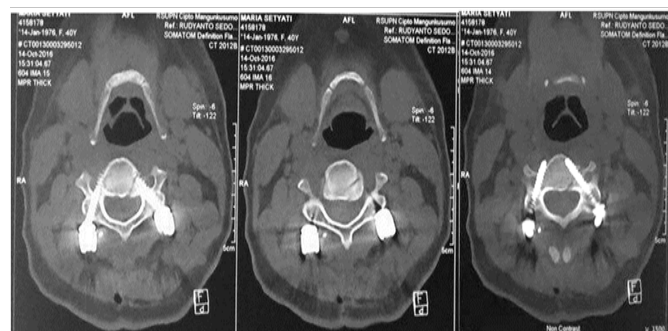
**Figure 4.** Cervical CT-scan of C3 vertebrae in axial plane showed there was a fracture line on left side of vertebral body, on the pedicle track. Left C2-C3 facet joint was also slightly subluxated.



**Figure 6.** T2-weighted image of non-contrast cervical MRI in sagittal plane.



**Figure 8.** Post-operative cervical plain radiographs.



**Figure 10.** Post-operative cervical CT-scan in axial plane of C3 vertebrae.

## RESULTS

After surgery, she was in stable condition and her neurological status remained excellent through the time. Post-operative plain radiographs and CT-scan are shown in Figure 8, 9 and 10. The patient was able to sit, stand, and walk after 3 days of surgery. She was discharged from the hospital 5 days after surgery.

## DISCUSSION

The patient was diagnosed with flexion tear drop fracture of C2 vertebrae as the radiographic images showed an avulsed fragment from the anterior-inferior angle of the body of the cervical spine (C2).<sup>6</sup>

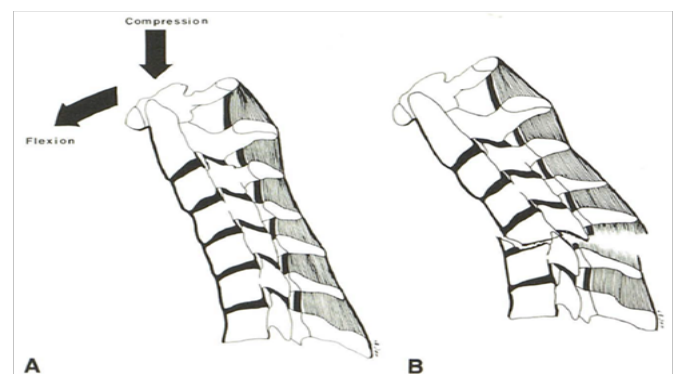
Although epidemiology shows that this kind of injury frequently happens with neurological deficits, in this case, the patient was in intact neurological status through the time. The main reason that this kind of fracture could cause neurological disturbance is because of the biomechanic nature of the injury mechanism. To cause such fracture, it must have needed a high energy forces which could tear such strong and stable anatomical structure around of the C2 vertebrae.

The tear-drop fracture is a result from the combination of forceful flexion and axial compression of the cervical spine. The anterior-inferior part of the vertebral body is fractured by a shear stress with compressive loading and the remaining portion of the vertebral body is displaced backward into the spinal canal. This reciprocal distractive force that occurs in the posterior column of the spine resulting in disruption of the posterior ligamentous structures.<sup>4</sup>

The motions of the cervical region from C2-C3 through C7-T1 are flexion, extension, lateral flexion and axial rotation. Usually, the range of extension of the lower cervical spine is greater than the flexion. The flexion motion is limited by the lips of the anterior and inferior aspect of the cervical vertebral bodies pressing against the anterior and the superior aspect of the vertebral bodies below.<sup>5</sup>

In this case, this kind of injury occurred in C2 vertebrae, which considered as more stable regarding its anatomical structures. Anatomically, the first two cervical vertebrae are structurally and developmentally different. The second cervical vertebrae, or axis, provides a bearing

surface on which the atlas (first cervical vertebrae) may rotate. Its most distinctive characteristic is that the vertically projecting odontoid process serves as a pivotal restraint against horizontal displacement of the atlas (Figure 11).<sup>7</sup> In our case, we predicted that some of the forces was passed through the adjacent vertebrae (C3), resulting in fracture of the left side C3 vertebral body and subluxation of the left C2-C3 facet joint. Thus, the injury forces were not massive enough to cause the posterior fragment of the C2 vertebrae displaced backward and injured the posterior ligament structures or even compromised the spinal cord. We did not find any evidence of ligamentous injury in this case based on the MRI findings.



**Figure 11.** Illustration of tear-drop fracture's mechanism of injury (A) and the resultant deformity (B).<sup>4</sup>

This kind of injury was thought to be unstable. Surgical procedure was performed to prevent spinal cord injury and further soft tissue damage and to achieve adequate stabilization. Therefore, early mobilization became possible and it helped preventing complications due to a long period of immobilization. Recently, there is a tendency that operative treatment is performed based on the advantages, such as cervical stabilization, early ambulation, shortened period of admission, easy nursing and improvement of mental health.<sup>2</sup>

In this case, we decided to do the surgery because the flexion tear drop fracture of the axis did not stand alone. We also found another fracture on the left side of the C3 vertebral body and on the left C2-C3 facet joint subluxation. The patient was a teacher with high demand daily activities. We could not risk the possibility of further spinal structural damage or even neurological disturbances. Conservative treatment using collar brace immobilization was thought to be uncomfortable.



We performed posterior stabilization using pedicle screws and rod system. We considered using pedicle screws instead of lateral masses because of its nature as the strongest structure of the vertebral bone. We also tried to reduce and compress the fracture of the C3 vertebrae using the pedicle screw. At pre-operative planning, we already measured the diameter and also the angle of the pedicles based on the CT-scan imaging. This acted as our guide to choose the size of the pedicle screws and the angle for insertion.

Anatomic studies have shown that the cervical pedicle height ranges from 5.1 to 9.5 mm, and width ranges from 3 to 7.5 mm.<sup>7</sup> In this patient, we used pedicle screws with 3.5 mm diameter and 30 mm length for C2 vertebrae and 26 mm length for C3 vertebrae.

The appropriate levels of fixation were confirmed intraoperatively by an image intensifier guidance. Pedicle screw fixation in cervical is considerably riskier than lateral mass screw due to its anatomical structure involving the vertebral artery. Vertebral artery that lies within its foramen is exactly lateral to the pedicle and nerve root that lies within the spinal canal is exactly medial to the pedicle. Some minor error of screw placement can cause harmful neurovascular injury. Malposition in sagittal plane can also risk the injury of the nerve roots in the foramina above or below the pedicle.<sup>8</sup>

Preoperative measurement was done before the surgery based on the pre-operative CT-scan image. The C2 pedicle screw insertion point was at the intersection between a line along the cranial leading edge of C2 lamina and a line along the midpoint of pars articular mediolaterally. The trajectory angulation was 30-45° to the medial and 30-45° to the cranial or aimed at the bottom half of the C1 tubercle. The insertion point of the pedicle screw in C3 was just below the facet joint at half way point between the medial and the lateral margins of the lateral mass. The trajectory angulation was 30° to the medial and 0-10° to the cranial.

The common surgical management for tear-drop vertebrae fracture is complete excision (corpectomy) and grafting of the vertebral body using anterior cervical surgical approach in order to perform effective spinal cord decompression to overcome the disruption of three columns and high potential of instability.<sup>2,3</sup> A case presented by Yue, JJ., *et al.* described a 17 year old ice hockey male athlete with tear-drop fracture of C5

vertebrae and transient quadriparesis. Standard anterior cervical fusion procedure was done through the left anterolateral approach. Discectomies of C4-5 and C5-6 followed by C5 corpectomy was done prior to tricortical iliac crest bone graft insertion and anterior plate fixation. The patient could move all extremities immediately after surgery. Non-union was noted at 5 months post-operative follow-up at C5-6 level. A bilateral posterior fusion was taken to deal with this problem.<sup>1</sup>

Kim, HJ., *et al.* analysed treatment outcome of 25 patients with cervical tear-drop fracture. All of flexion type cases underwent anterior plate fixation using cervical locking plates via anterior surgical approach. For the cases of extension type, conservative treatment by Philadelphia neck brace for 12 weeks was chosen due to its lack of instability. There were no cases with worsen post-operative neurologic deficits. All nerve roots injuries were fully recovered. The incomplete spinal cord injuries showed an average grade of recovery. In extension type of cervical tear drop fracture, if there is posterior ligament injury, surgical treatment is also recommended.<sup>2</sup>

Another study by Signoret, F., *et al.* described a posterior approach to reduce and fixate the cervical vertebrae using three-hole cervical plates in 8 patients. The idea was to adequately reduced the whole fracture displacement in a single process by acting on the lateral masses of the fractured vertebrae. They evaluated the effectiveness of this method in subaxial (C5-C7) flexion tear-drop fractures. The result was satisfying. There was no residual local kyphosis, residual posterior slippage, spinous process distance enlargement or articular space widening. Normal lordosis was restored. Satisfactory restoration of anatomy was successfully achieved. Radiologic healing of the antero-inferior wedge fragment was achieved by 3 months in all cases. The intention for doing the posterior approach instead of the standard anterior approach was its simplicity. Fracture was treated with a single approach with no bone excision and bone graft needed.<sup>3</sup>

Spinal decompression and plate fixation via anterior surgical approach is considered suitable for unstable flexible cervical tear-drop fracture. We can perform the procedure with the patient in a supine position. There will be less risk of soft tissue damage by using anatomical approach and maintaining the normal cervical curvature will be easier. For posterior fixation, there will be some difficulties in position changes, especially in multi-level spinal cord injury patients. However, significant stability

and reduced dislocation, which is unable to achieve with manual reduction, in cervical spine fracture, are hard to realize if conducted by anterior fixation alone. Posterior fixation may be considered for the cases in which stability can not be maintained after anterior interbody fusion.<sup>2</sup> Complication in using a single use of an anterior surgical approach is early dislodgement of the bone graft. It may lead to instability and kyphotic angulation may further occur too. To resolve these problems, prolong skeletal traction application, combined anterior and posterior stabilization approach, or anterior decompression with plate fixation could become the alternative methods.<sup>2</sup>

## CONCLUSION

Flexion tear-drop fracture of C2 vertebrae (the axis) is considered as a rare case. Although it is common for this kind of injury clinically appeared with neurological impairment, we did not found any neurological deficits in this case. It was thought to be a combination of flexion and axial-compressive injury that cause this kind of fracture. Beside a fracture on the C2 vertebrae, it was also found a fracture on the C3 vertebrae. Due to its common instability problem following this pattern of injury, we decided to do a surgical procedure for this patient. The patient underwent posterior stabilization procedure using pedicle screws and rods. Further evaluation on this patient showed a very good outcome. The patient did not have any neurological deficit complaint and could do her previous daily activities and routines normally.

## Acknowledgement

We thank the patient for allowing us to share her details, and thank to all of author's teacher, especially the Consultant of Spine, Department of Orthopaedic & Traumatology, Cipto Mangunkusumo National Central Hospital, and Faculty of Medicine, Universitas Indonesia.

## REFERENCES

1. Yue, JJ., Ivancic, PC., Scott, DL. Teardrop fracture following head-first impact in an ice hockey player: Case report and analysis of injury mechanisms. *International Journal of Spine Surgery*. Volume 10 Article 9. DOI: 10.14444/3009. Published February 3<sup>rd</sup>, 2016.
2. Kim, HJ., Lee, KY., Kim, WC. Treatment Outcome of Cervical Tear Drop Fracture. *Asian Spine Journal*, Vol.3, No.2, pp 73-79, 2009.
3. Signoret, F., Jacquot, FP., Feron, JM. Reducing the cervical flexion tear-drop fracture with a posterior approach and plating technique: an original method. *Eur Spine J* (1999) 8 : 110-117.
4. Kim, KS., Chen, HH., Russell, EJ., Rogers, LF. Flexion Teardrop Fracture of the Cervical Spine: Radiographic Characteristics. *AJNR* 9: 1221-1228, November/December 1988.
5. Ooi, SS., Wong, SV., Radin Umar, RS., Azhar, AA., Teap, JS., Megat Ahmad, MMH. Mechanisms of Cervical Spine Injuries for Non-Fatal Motorcycle Road Crash. *Med J Malaysia*, Vol.59, No.2, June 2004.
6. Agrawal, A., Rao GM. Isolated tear-drop fracture of the axis without neurological deficits. *The Indian Journal of Neurotrauma II* (2014) 68-70. Published December 15<sup>th</sup>, 2013.
7. Herkowitz, HN., Garfin, SR., Eismont, FJ., Bell, GR., Balderston, RA. Rothman-Simeone, *The Spine*, Sixth Edition, Volume 1, Philadelphia: Elsevier Saunders, 2011.
8. AO Foundation. Cervical pedicle screw insertion. [https://www2.aofoundation.org/wps/portal/!ut/p/a0/04\\_Sj9CPykssy0xPLMnMz0vMAfGjzOKN\\_A0M3D2DDbz9\\_UMMDRyDXQ3dw9wMDAx8jfULsh0VAdAsNSU!/?soloState=true&contentUrl=/srg/popup/additional\\_material/52/X140\\_CervPedScr.jsp](https://www2.aofoundation.org/wps/portal/!ut/p/a0/04_Sj9CPykssy0xPLMnMz0vMAfGjzOKN_A0M3D2DDbz9_UMMDRyDXQ3dw9wMDAx8jfULsh0VAdAsNSU!/?soloState=true&contentUrl=/srg/popup/additional_material/52/X140_CervPedScr.jsp) (Downloaded at March 28<sup>th</sup>, 2017)