Krishnan *et al.*
Egyptian Journal of Neurosurgery (2022) 37:32
https://doi.org/10.1186/s41984-022-00165-x

Egyptian Journal of Neurosurgery

TECHNICAL NOTE

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Transpedicular vertebral biopsy under O-arm navigation: a technical note

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Abstract

Background: Despite emerging techniques, sample inadequacy remains the most important factor that necessitates need for repeat biopsy. Transpedicular Biopsy has diagnostic accuracy ranging from 75 to 90% in both computed tomography guided or percutaneous C-arm guided biopsy. Presenting in this article is an add on technique as a modification to enhance quality and quantity of sample obtained using a self designed trocar cannula with computed tomography-based Navigation.

Main body: We have used transpedicular biopsy technique under C Arm fluoroscopy, previously, where we used a self-designed trocar and cannula in our study of 71 cases & reported an accuracy of 88.7% with no reported complications. This is add on modification of same technique where under 3D navigation, we introduce a pituitary forceps through a correctly positioned cannula. This helps for biopsy of soft lesions/ discal level pathologies. Also, multi-planar adjustment of cannula after initial Stealth O-Arm navigation helps in sampling of different regions of vertebral body by reinsertion of pituitary forceps with simple manipulation of cannula without withdrawal. This minimizes risk of fracturing pedicle. With our technical modification, cannulated drill bit with core opening can be drilled through cannula to retrieve a sample. Our technique has limitations being experience driven and also enabling technology dependent. However, same method can be applied using 2-dimensional fluoroscopy without navigation.

Conclusion: Our technique of using pituitary forceps through cannula is highly effective in getting adequate representative sample with spectrum ranging from hard sclerotic lesions to soft lesions and discal pathologies. This procedure can be used with traditional 2-dimensional fluoroscopy as well as with 3-dimensional navigated precision.

Keywords: Biopsy, Transpedicular, Trocar, Navigated, O-arm

Background

Symptomatic vertebral and disco-vertebral lesions are often detected radiologically but are diagnosed with variable accuracy ranging from 95% for lytic lesions to 42% for mixed pathologies [1]. Management of spinal lesions depends largely on highly specific modalities like biopsy and histopathology. The first ever transpedicular (TP) biopsy (TPB) was performed by Stringham et al. in 1994 [2, 3]. The pedicle has been used as a gateway to vertebral body either via open or minimally invasive (MIS) methods owing to our understanding of the vertebral anatomy and experience with TP fixation. Despite emerging techniques, sample inadequacy remains the most important factor that necessitates the need for a repeat biopsy. The TPB has a diagnostic accuracy ranging from 75 to 90% in both Computed Tomography (CT) guided radiodiagnostic center biopsy as well as percutaneous biopsy in operation theater [2]. Presenting here in this article is an add on technique as a modification to enhance the quality and quantity of sample obtained by using a biopsy cannula. This increases the diagnostic yield of TPB, in turn guiding toward an appropriate line of management.

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The authors have utilized the same cannula that was used for the percutaneous continuous drainage [4] of psoas abscess and TPB [2].

Main text

Case example: 46-year-old male presented to our tertiary care spine institute with complaints of back pain and neurological deficit. Imaging investigation revealed a pathological fracture of the L3 vertebral body (Fig. 1). CT scan showed a lytic lesion involving the body of L3 and the left pedicle. MRI did not reveal any compression of the neural elements and the Bilsky score [5] was 0. His SINS score [6] was 10. PET-CT revealed it was a solitary lytic lesion with high FDG uptake and no lesions were found elsewhere. He was planned for surgery in view of instability as per the SINS score and to obtain a biopsy. Surgery performed was L2-4 percutaneous pedicle screw stabilization with L3 left sided TPB. The histopathology report was suggestive of plasmacytoma.

Technique: This biopsy was performed under general anesthesia (GA) [7] using intra-operative O-Arm-Navigation (Medtronic SN BI8021593, Navigation—Medtronic S8 SN- N07534178) with the patient in prone position on a radiolucent operating table. Projection image of navigation was used to mark the skin entry site on left side and target the pediculo-facet groove with the TPB cannula. It was at the level of L3 vertebra on the right side 7 cm from the midline. Through a small stab incision, the Stealth navigated Jamshedi needle (JN) (PAK-Pedicle Access Kit, Medtronic) was introduced under O-arm guidance. The entry & direction of JN was adjusted according to the location of the lesion and progressed further to land at faceto-transverse groove at 2' O clock position. The JN under navigation was introduced till the posterior border of vertebra and pediculo-body junction was reached. Guide wire was then put across and JN removed. On the guide wire, the first dilator of percutaneous screw (Sextant- Medtronic) was put. Then it was removed and on the guide wire, the calibrated self designed TBP cannula

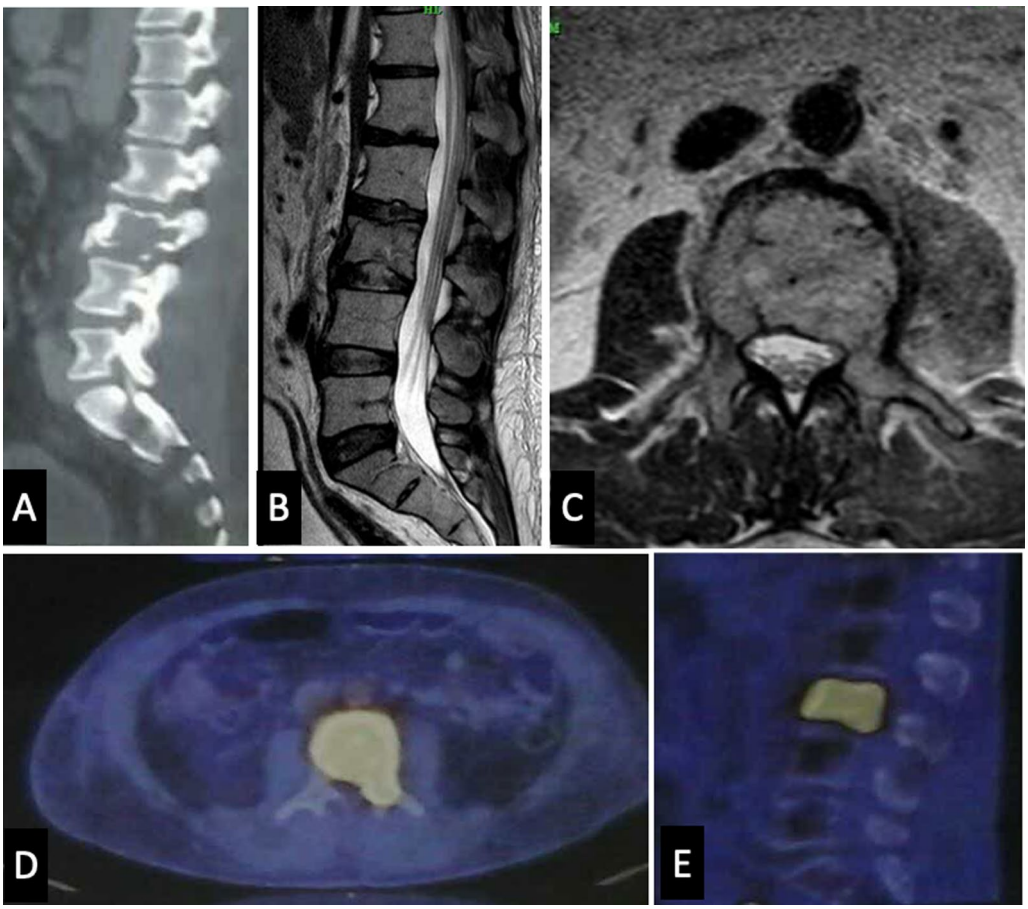

Fig. 1 **A**, **B**, **C** CT Scan sagittal, MRI sagittal T2 sequence, MRI T2 axial sequence showing L3 vertebral affection predominant left side with beyond pars involvement. **D**, **E** PET scan showing high FDG uptake

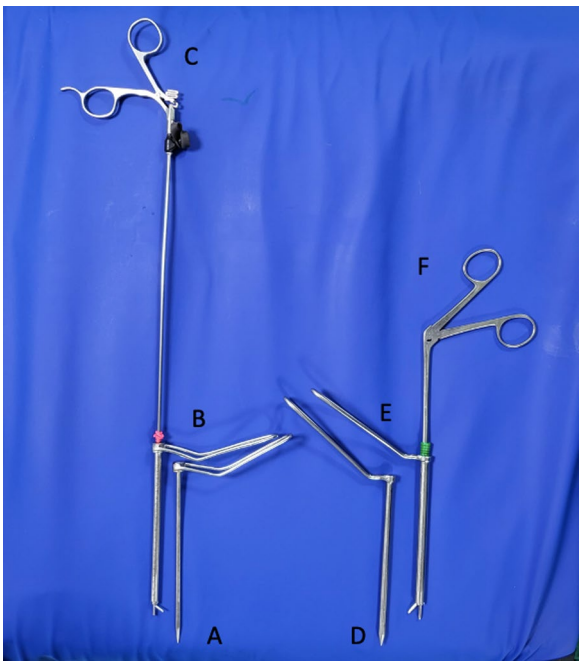

Fig. 2 5 mm Calibrated Biopsy cannula (**B**) with its trocar (**A**) and calibrated endoscopic 2.5 mm grasper (**C**) with Red Stopper working at a pre-decided length. This is used for only diagnostic biopsy cases under general anaesthesia. Bigger 8 mm cannula (**E**), trocar (**D**), 3.5 mm disc punch with Green stopper (**F**) are used when per-operative biopsy is contemplated

(Fig. 2), with third party navigation frame attached was advanced till medial border of the pedicle was clearly seen on AP Navigation screen view. We utilize a 5 mm calibrated Biopsy cannula with endoscopic 2.5 mm grasper for diagnostic biopsy under GA. Bigger 8 mm cannula, trocar with 3.5 mm disc punch are used when per-operative biopsy is contemplated (Fig. 2). As a thumb rule, the ring tip of the TBP cannula should not cross the posterior wall of the vertebral body as seen on lateral view. Otherwise for the TP route, the index instrument will penetrate the spinal canal with a risk of neurological injury. After confirming this position, the serrated cannula was advanced to the body. The cannula was positioned in the posterior one third of body as it reaches the point where it just meets the lesion as confirmed by visual eye-balling of the MRI image and 2D confirmation with the O Arm (Fig. 3). Thereafter a 16 cm long and 3.5 mm thick pituitary forceps was introduced through the cannula and under fluoroscopic guidance samples were obtained with the pituitary forceps (Figs. 3 and 4). A stopper was applied on the forceps to avoid any accidental breach beyond the margin of the vertebral body. The stopper reduces the radiographic shoots significantly. This was repeated several times in different directions till an adequate sample was obtained. Abgel was pushed in before withdrawing and a stitch was taken. Percutaneous pedicle screws were inserted under O arm guidance and surgery was accomplished.

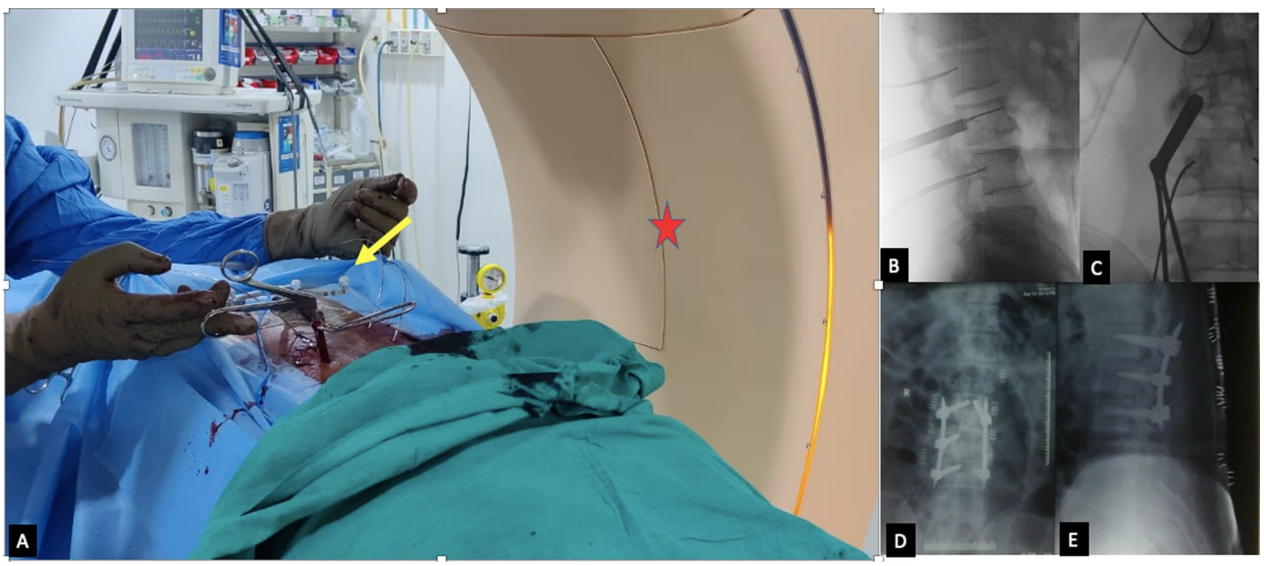

Fig. 3 **A** O Arm being used for 2D confirmation (Red star) and navigation patient frame(yellow) with the calibrated biopsy cannula housing the disc punch with a stopper. **B**, **C** The 2D image taken to After Navigated Positioning of guide wires for screw and Biopsy cannula, confirms the position of the tip of cannula which is beyond the neural canal margin. **D**, **E** Final 5 screws percutaneous Sextant (Medtronic) Fixation construct

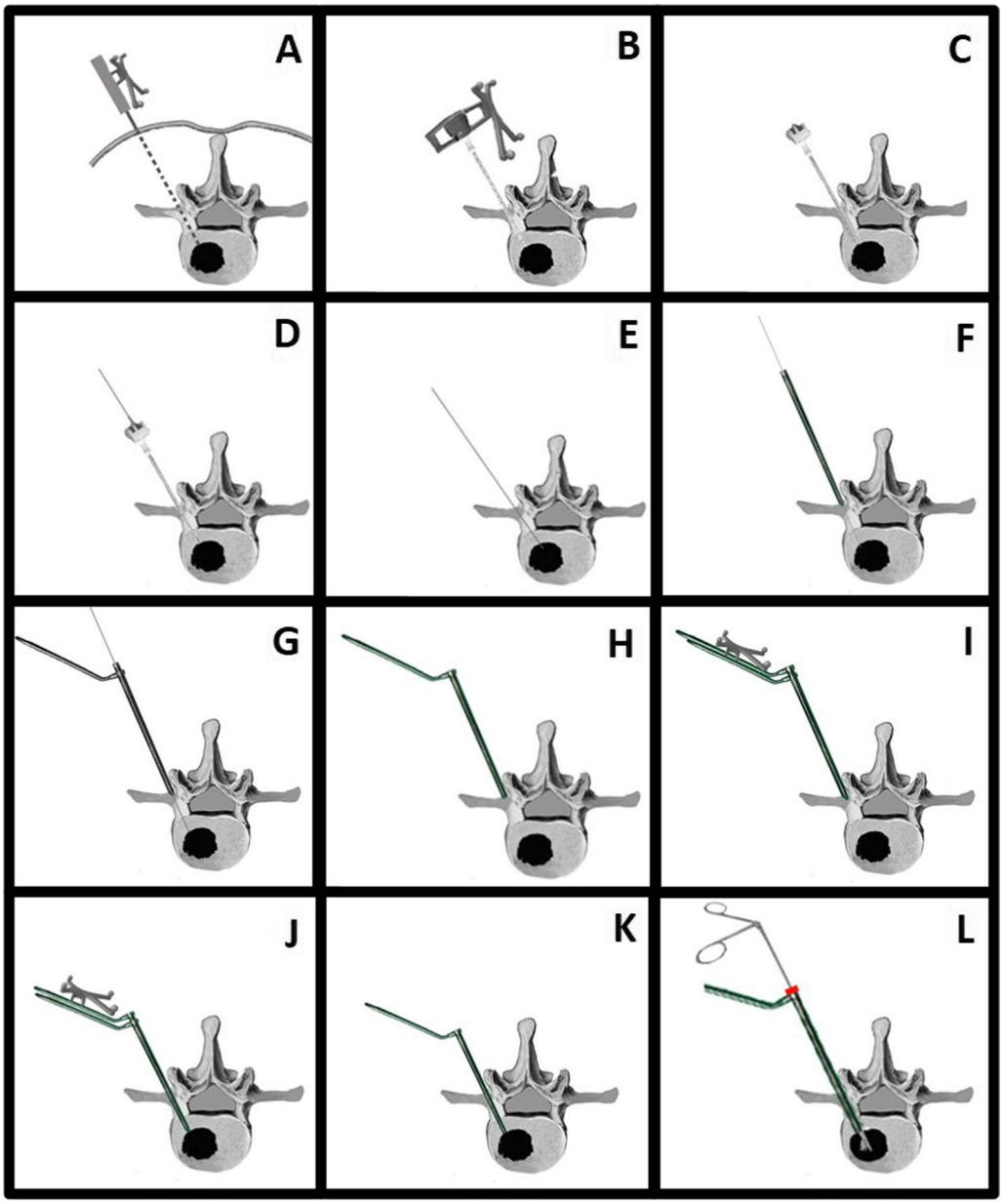

Fig. 4 Illustration showing steps of the biopsy. **A** Navigated PAK (Pedicle access Kit, Medtronic) needle used to get projection and then skin stab incision is put. **B** PAK needle is introduced and pushed to land at pediculo-facet junction. **C** Its trocar is introduced further to reach beyond the posterior border of body under virtual images on navigation screen. **D** Trocar is withdrawn. **E** Guide wire is introduced positioned into the vertebral body. **F** The outer sheath of PAK is removed. **G** Dilator is put on guidewire. **H** Serrated Biopsy canula is put on the dilator & guide wire to reach pediculo-facet junction **I** Then guide pin & dilator are removed. **J** The third party tracker guided trocar is introduced and is further pushed to reach in vertebral body safely at or beyond the pedicle to body junction under virtual images of navigation. **K** The trocar is removed. **L** The pre-calculated length of biopsy forceps is introduced and is used as per the location of biopsy target lesion with a stopper. Single shoot 2D is taken beforehand to confirm the position and safety

Discussion

Open biopsy is the gold standard procedure with 98% accuracy but associated with additional morbidity [8]. For two decades, percutaneous procedures have gained popularity. CT-guided percutaneous core needle biopsy is a quick, economical and safe procedure. Yang et al. showed that core needle biopsy had an accuracy of more than 90% for detecting highly malignant lesions [9, 10]. In case of bone, an induced stress fracture by rotation of the JN usually gives an adequate sample. But, specially in

very soft lesion the sample procured does not always adequate. Brugieres et al. also found this intervention more reliable in diagnosing osteolytic lesions but the accuracy dropped to 75% when dealing with sclerotic lesions [1]. With our technical modification, even a cannulated drill bit, with stopper and with a core opening can be drilled through the cannula to retrieve safe adequate sample. Thus, the spectrum of TPB will range from hard sclerotic lesions to soft lesions with this modification. Nourbakhsh et al. described adequacy of the sample which is stated to be the percentage of sample required for the pathologist to make the diagnosis [11]. In a study by Kornblum et al. CT guided biopsy showed promise in terms of sample adequacy; however, they found a lower accuracy rate in the thoracic spine [12]. Rimondi et al. in one the largest studies on CT guided biopsies of the spine showed an improvement in histopathological diagnostic accuracy of 93.3%. However, 5% of their cases needed repeat biopsies due to sample inadequacy and they also reported a complication rate of 2.1%. They concluded that the success of CT guided biopsy is higher in malignant lesions both primary and secondary but is low in chronic inflammatory lesions [13]. We have used this technique previously where we used a self-designed trocar and cannula in our study of 71 cases & reported an accuracy of 88.7% with no reported complications. This is a modification of the same technique where we additionally introduce a pituitary forceps that helps for biopsy of vertebral lesions as well as discal level pathologies [2]. Also, the multi-planner adjustment of the cannula after the initial Stealth O-Arm navigation helps in sampling of different regions of the vertebral body by reinsertion of the pituitary forceps with simple manipulation of the cannula without withdrawing it. This minimizes the risk of fracturing the pedicle. Our institutes biopsy success report has increased even further (unpublished) by the above technique. Another major problem with C-arm guided biopsy is its limited visibility in the upper thoracic lesions due to shoulder, scapula and lung shadows with respiratory movements. In obese and osteoporotic patients, the 2D image is unpredictably poor.

With adequate knowledge of the vertebral morphometry and experience with TP fixation, the TP route is an important passage for obtaining biopsy. It can accommodate a variety of instruments and has made the entire vertebral body accessible. The safety angulation of instruments in both sagittal and axial planes is significantly increased if it is done with navigation, especially under GA, while definitive fixation is also being carried out. When performed percutaneously it reduces the morbidity and minimizes complications. In a similar previous report, Basu et al. in their analysis of 26 patients had a sample adequacy of 88.4% using the eleven-gauge J needle. However, additional instruments like the curette or disc forceps were used in 14.2% patients when the sample was inadequate. Basu et al. used the J trocar biopsy set in their study of 39 cases. Their sample adequacy was 84.6% which improved to 100% by adopting intra-operative cytology which allowed repeating the biopsy in the same sitting [14]. This is due to the use of the drill and the pituitary forceps which are easily passed through the kypho-plasty cannula thus obtaining adequate samples. Diagnosing soft tissue lesions (Discitis) using this simple technique is superior as adequate disc material can be obtained with the pituitary forceps passed through the cannula trans-foraminally which would otherwise be difficult when a trocar is passed and also would largely depend on the surgeon's experience. Krishnan et al. in their technical note and review on percutaneous endoscopy discectomy and drainage (PTELDD) have stated the superiority of the intervention over CT guided biopsy in terms of success rate and culture bacterial recovery [15]. Another similar technique under navigation is also reported by Takata et al. [16]. They also did biopsy under GA but the diameter of cannula was 5 mm with special pituitary forceps with stopper.

Our technique has limitations being experience driven and also enabling technology (Stealth-O Arm Navigation) dependent. Performing this procedure does not require multiple CT scans as against in CT guided biopsy. Thus, radiation exposure to the patient is reduced. Also, CT-guided biopsy has the biggest disadvantage of not being done in the sterile operating room environment. We usually in 3D navigated TPB, use a small field of view, low-dose mode for the O-arm 3D scan to reduce radiation to the patient. With this technique, we can reduce radiation exposure to operating room staff too. There were similar findings reported in a study by Tanaka et al. in 2021 [16]. However, the same method can be applied using 2D fluoroscopy without navigation [17, 18]. Oblique "scotty dog" view can be used by novice surgeons and routine AP can be also used by experienced surgeons. This was a technique description and not a series description, which would have given more diagnostic accuracy statistically regarding the size, location, region, tissue disease and hard-soft morphology. Also, we cannot comment on the quality/ quantity of the specimen without having a comparative study with a control group and that is a potential limitation. Biopsies being integral for diagnosis at times are misdiagnosed as well. As per our institutional protocol, we always send the primary slide reporting for a second pathos-microbiologist opinion for reconfirmation especially in a precious biopsy. At times, simultaneous two laboratory/institute tissue processing is also done as there is no dearth of material procured by our method, making the tissue diagnosis even more reliable.

A navigated cannula with stopper, scale markings integrated with the Original Equipment manufacturers would be a better standardized solution though.

The TPB has proven to be an important intervention in the spine surgeons armamentarium with excellent accuracy [19]. We hope that with our technical modification, the diagnostic yield, accuracy of sampling and adequacy of sample will improve even further.

Conclusions

Percutaneous TPB has evolved as the intervention of choice in diagnosing radiologically proven vertebral body lesions. Our technique of using pituitary forceps through a cannula is highly effective in getting an adequate representative sample with a spectrum ranging from hard sclerotic lesions to soft lesions. This procedure can be used with traditional 2D fluoroscopy as well as with 3D navigated precision.

Abbreviations

TP: Transpedicular; TPB: Transpedicular biopsy; MIS: Minimally invasive spine surgery; CT: Computed Tomography; MRI: Magnetic Resonance Imaging; SINS: Spinal Instability Neoplastic Score; PET: Positron Emission Tomography; GA: General Anesthesia; JN: Jamshidi Needle; PAK: Pedicle access kit; AP: Anteroposterior; PTELDD: Percutaneous endoscopy discectomy and drainage.

Acknowledgments

Not applicable.

Author contributions

(I) Conception and design: AK (II) literature search, Collection, analysis and interpretation of data and Manuscript writing: AK, NM (III) Images: AK, NM (VII) Administrative support, Institutional Head: BRD (V) Final approval of manuscript: All authors.

Funding

No sources of funding to declare.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Ethics approval and consent to participate obtained. CTRI number—CTRI/2022/02/040500.

Consent for publication

All images anonymized and consent to publish taken.

Competing interests

The authors declare that they have no competing interests.

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Received: 18 March 2022 Accepted: 18 June 2022
Published online: 22 August 2022

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