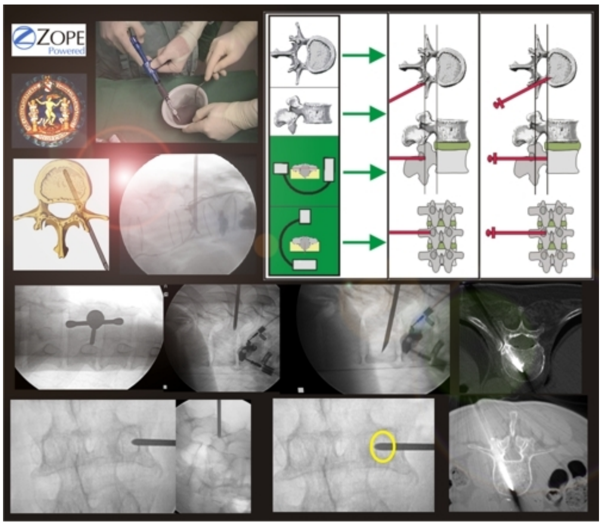
Percutaneous Vertebroplasty under Fluoroscopy Guidance: Needle Placement Technique



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1) Introduction

Fig. 1: Percutaneous Cementoplasty (PC, vertebral packing, vertebroplasty).

Percutaneous Cementoplasty (PC, vertebral packing, vertebroplasty) with acrylic cement (polymethylmethacrylate: PMMA) is a procedure aimed at preventing vertebral body collapse and pain in patients with pathological vertebral bodies. Percutaneous vertebroplasty is used increasingly in the treatment of osteoporotic fractures and malignant disease of the thoracic, lumbar, and, cervical vertebral bodies.

Percutaneous vertebroplasty is usually performed under fluoroscopy guidance. A combination of CT and fluoroscopy provides a safer and easier guidance especially in difficult cases. However, this type of equipment is not commonly available in all departments.

Percutaneous Cementoplasty technique with fluoroscopic guidance is described with an interactive step by step hypertext-based teaching file. The technique of vertebroplasty is reported for cervical, thoracic, and lumbar levels. Performing this procedure requires advanced imaging skills and special training.

2) Equipment

Biplane or singleplane fluoroscopy technique.

Facilitating the rapid acquisition of guidance information in two planes, biplane fluoroscopic equipment is particularly recommended for beginners. If a biplane system is not available, one may be simulated by adding a mobile C-arm to the room with a fixed single-plane system, thus creating temporary biplane configuration that will speed the procedure. The higher quality image should be used for lateral projection because that projection is the most critical for monitoring cement injection.

The biplane fluoroscopic equipment allows multiplanar, real-time visualization for cannula introduction and cement injection and distribution in the vertebral body. Rapid alternation between imaging planes is possible without complex equipment moves or projection realignment.

Fig. 1: "Biplane" fluoroscopic equipment. (ST. Thomas Hospital London UK). The higher quality image should be used for lateral projection allowing the precise monitoring of cement injection.

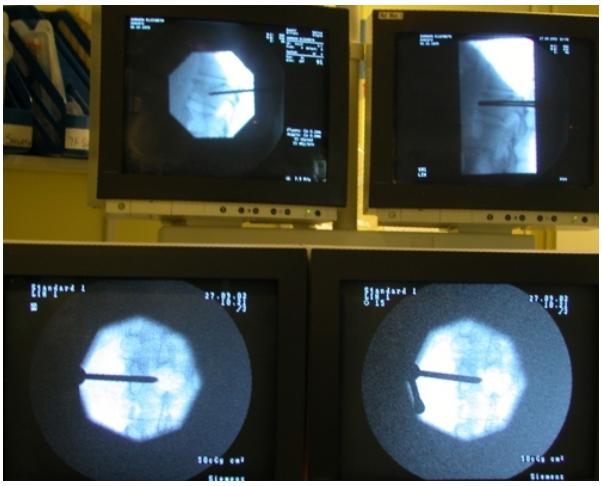


Fig. 2: Biplane fluoroscopy.

Patient positioning

Patient position and entry point

- For thoracic and lumbar procedures, the patient is in prone position. The optimal approach is transpedicular or posterolateral in lumbar level. Transpedicular or intercostovertebral routes are the optimal approaches in the thoracic level. The pedicles of the upper thoracic spine can accommodate 15-gauge needles.
- For cervical procedures, anterolateral approach is recommended. Transoral approach can be used for C2.
- To facilitate the procedure, the approach should be visualized on a preprocedural CT scan (or axial MR imaging). The entry point and its distance from the midline (spinous process) can be measured on the preprocedural CT scan or MR films.
- The pathway must avoid vascular, visceral and neural structures. The use of CT for the planning of the pathway and positioning of the needle allows a medial positioning of the needle tip in the anterior third of the vertebral body in thoracic and lumbar procedures. Thus a controlateral access is seldom necessary to obtain a good vertebral filling.
- Cortical perforation can require the aid of a surgical hammer.
- For thoracic and lumbar procedures, the optimal needle position is the anterior third of the vertebral body or the anterior portion of the tumor.

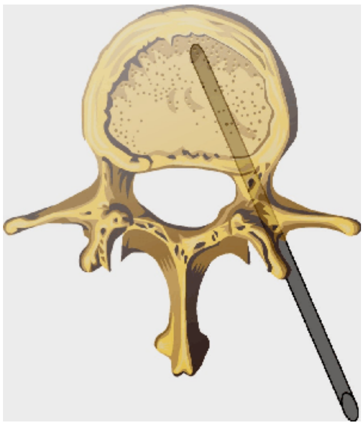


Fig. 1: Lumbar procedure. Transpedicular approach.

Fig. 2: Transpedicular procedure. Optimal needle position in lateral projection

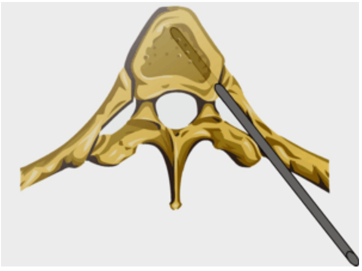


Fig. 3: Thoracic approach. Intercostovertebral route.

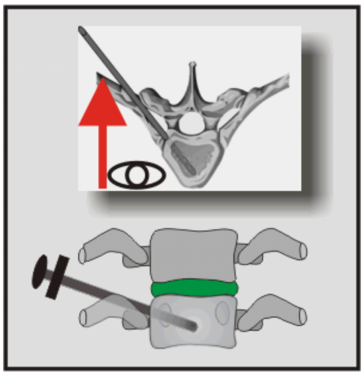


Fig. 4: Intercostovertebral route.

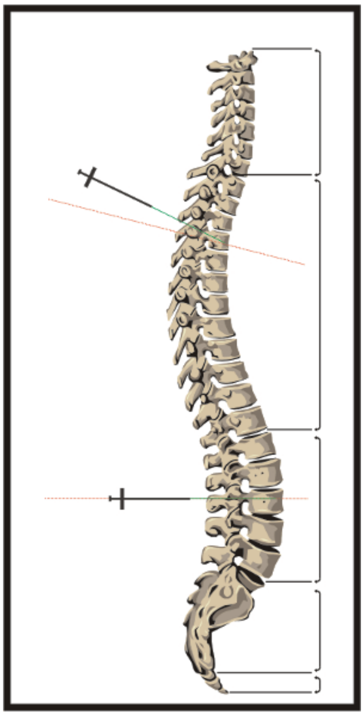


Fig. 5: Changes in angle of approach. The angle varies from 0° in a lumbar L3 transpedicular route to 20 and 30 ° in a thoracic intercostovertebral route. The needle should be always in the axis of the vertebral body.

3) Local anesthesia

The procedure is performed under local anesthesia usually combined with conscious sedation. The 22-gauge spinal needle is used for local anesthesia and as a pilot needle for the vertebroplasty needle (Tandem technique).

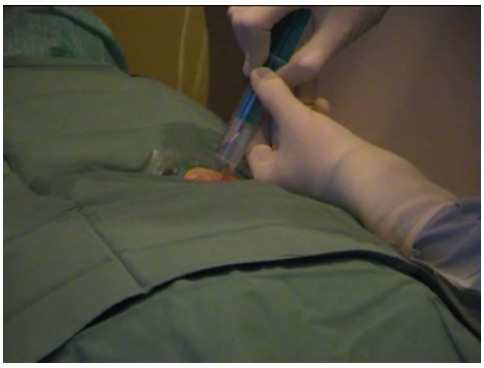
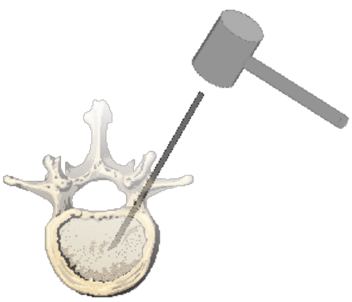


Fig. 1: Local anesthesia.

4) Needle Manipulation Techniques



Use of the needle bevel to control the direction of the needle:

- At the entry point, with a stiff needle, the direction can still be corrected only by changing directly the angulation (see Fig. 1). However, after deep penetration in bone, the needle angulation is difficult to modify. Therefore the needle direction should be adjusted by this method before deep bone penetration.
- After cortical perforation. Once deep inside bone it is usually not anymore possible to change the direction of the needle directly. We prefer the beveled vertebroplasty needles for this reason. A notch exists on one side of the hub that corresponds to the side of the bevel face (Fig.2). Once in bone, the needle bevel can be used to adjust slightly the direction of the needle Even, cement distribution can be adapted in the vertebral body by modifying the bevel direction during injection. Because the beveled needle tip is wedge shaped, this facilitates directional needle placement. It works even when the needle is deep inside the vertebral body. According to the bevel face direction (right, left, up or down) the course of the needle is modified. The needle is forced in a direction opposite to the bevel face. For example, when the bevel face and the notch are cephalad then the bevel face is pointed cephalad and the needle will be directed caudad. This technique allows an optimal placement of the vertebroplasty needle (see Fig.3 to 7).The stylet should always remain within the cannula during needle placement.

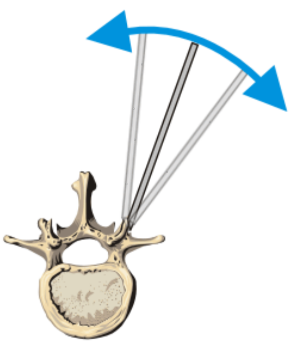


Fig. 1: Needle positioning before penetration of the coratical bone. Once the sharp tip of the needle is inserted in the periosteum, the needle direction can be modified by changing the angulation at the entry point.

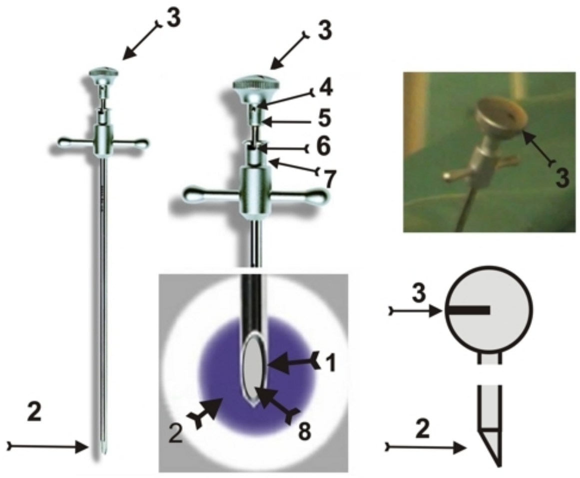


Fig. 2: Percutaneous Cementoplasty Cemento® set (Optimed/Germany), 10-gauge needle, handy metal wings for an easy insertion / removal and easy rotation of the needle, special beveled edge (arrow 2). Notch indicating the bevel face (arrow 6 &7) Metal protrusion to fix the stylet (arrow 4) on the hub (arrow 5). The outer cannula (arrow 1). The bevel face (arrow 8).

The principle of the vertebroplasty needle bevel:

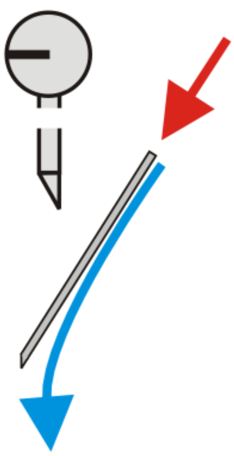


Fig. 3: The hub notch in medial position, bevel tip in medial position leading the course of the needle to the side (blue arrow).

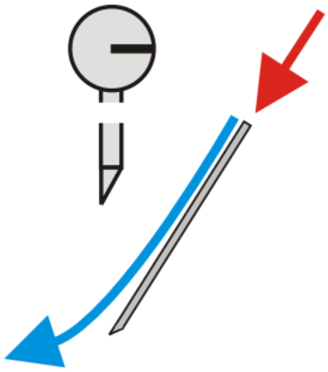


Fig. 4: The hub notch in side position, bevel tip in lateral position leading the course of the needle medially (blue arrow).

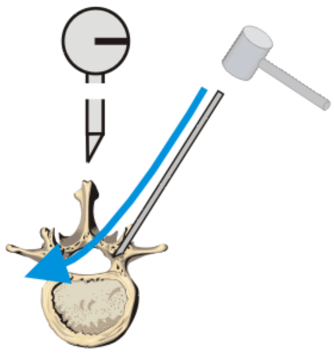


Fig. 5: The hub notch in side position, bevel face in lateral position leading the course of the needle medially (blue arrow). The needle is in contact with the spinal canal, it should be corrected.

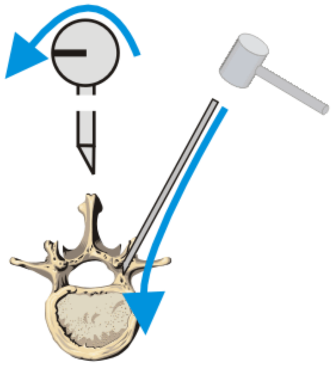


Fig. 6: Changing the bevel face direction by turning the connector 180°. The hub notch in medial position, bevel face in medial position leading the course of the needle to the side (blue arrow).

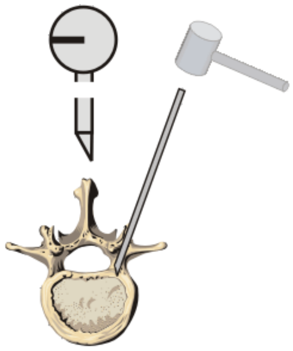


Fig. 7: Hammering, needle course correction.

5) Technique : Thoracic procedure

- The patient is positioned prone. Some patients cannot remain in a prone position and are placed three-quarter prone; the flexibility of the C-arm system allows the operator to adjust for these differences.
- The optimal approaches are transpedicular or intercostovertebral. The pedicles of the upper thoracic spine can accommodate 15-gauge needles. For transpedicular technique see lumbar level.
- Exclusive fluoroscopy guidance requires two fluoroscopic views to be able to appreciate the exact needle position. Biplane fluoroscopic equipment facilitates the rapid acquisition of guidance information in two planes. It takes longer with a single-plane than with a biplane system, but it is feasible to use a single-plane fluoroscopic system.
- The intercostovertebral approach: The thoracic spine is reached via an oblique, posterolateral, intercostal approach at an angle 35° from the patient's sagittal plane. Preoperative CT scan determines the entry point (Fig.1). For an optimal approach, the entry point and its distance from the midline (spinous process) can be measured on the axial CT scan or MR film of the patient.

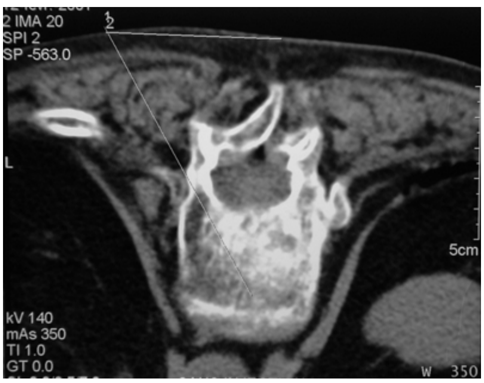


Fig. 1: Preoperative CT-scan determines the entry point.

- The entry point and angulation must be chosen to allow the placement of the needle tip in the anterior third of the vertebral body by using intercostovertebral approach. The pathway must avoid vascular, visceral and neural structures.
- The puncture point is located at the level of the pathologic vertebral body, 4.5-5 cm from the midline (preoperative CT scan measurement). The appropriate oblique projection requires a 30-35° angulation of the anteroposterior fluoroscopy tube.

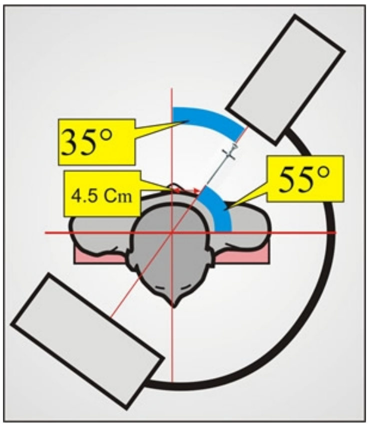


Fig. 2: Intercostovertebral technique (Laredo Technique). Posterolateral, intercostal approach at an angle 35° from the patient's sagittal plane.

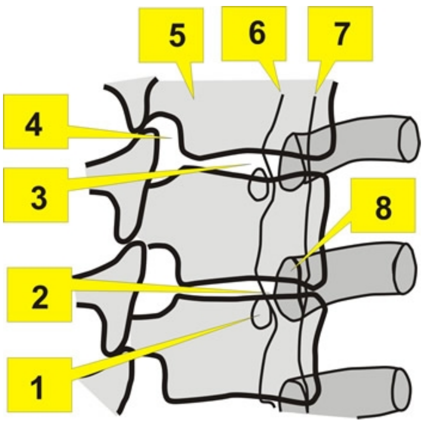


Fig. 3: Diagram of anatomical relations in 35° oblique procubitus position (oblique projection 35°). 1 Transverse process. 2 Costovertebral joint. 3 Disk. 4 Controlateral lamina. 5 Vertebral body. 6 External edge of the articular process. 7 Line of pleural reflection. 8 Rib head.

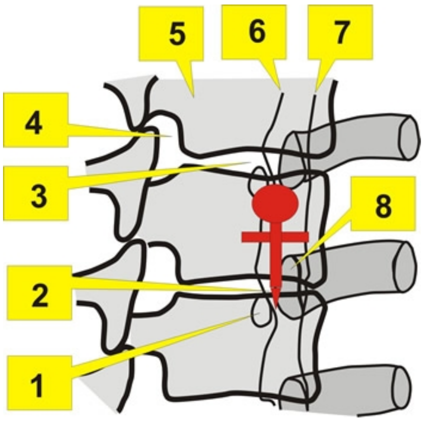


Fig. 4: Puncture showed in red represents the cementoplasty needle under oblique fluoroscopy control. Posterolateral, intercostal approach at an angle 35° from the patient's sagittal plane.

- 22-gauge spinal needle is used for local anesthesia and is advanced to the costovertebral joint under fluoroscopic control. A 10-gauge vertebroplasty needle is placed parallel to the 22-gauge needle using the same pathway. The vertebroplasty needle is advanced under fluoroscopic control (oblique projection) in the direction of X-ray beam. On oblique projection, the head of the adjacent rib defines the direction of puncture. Once the needle is in contact with the vertebral body, the lateral projection is used for insertion of the needle in the anterior one third of the vertebrae. Use the AP projection to ensure that the needle tip approaches or extends beyond the midline (see movie, case).

6) Technique : Lumbar Procedure: Unipediculate approach "stay in the ring" technique

- The patient is positioned prone. Some patients cannot remain in a prone position and are placed three-quarter prone; the flexibility of the C-arm system allows the operator to adjust for these differences.
- Exclusive fluoroscopy guidance requires two fluoroscopic views to be able to appreciate the exact needle position. Biplane fluoroscopic equipment facilitates the rapid acquisition of guidance information in two planes. It takes longer with a single-plane than with a biplane system, but it is feasible to use a single-plane fluoroscopic system.
- We use the unipediculate approach in percutaneous vertebroplasty which allows filling of both vertebral halves from a single puncture site (96% of cases) with no statistically significant difference in clinical outcome compared to bipediculate vertebroplasty.

- To facilitate the procedure, the approach should be visualized on a preprocedural CT scan (or axial MR imaging). The entry point and its distance from the midline (spinous process) can be measured on the preprocedural CT scan or MR films. A paramedian line lateral and parallel to the midline is drawn depending on the measurement performed on the previous CT or MR scan (approximately 5 cm, see case 2). The site of insertion of the needle is the point of crossing the paramedian line with the level of the vertebral body (lateral fluoroscopy). This measured distance is marked on the patient skin.
- Place a pilot spinal (22-gauge) needle into the soft tissues at marked level,
- Advance spinal needle to the pedicle and confirm position. Use the Tandem technique to insert the vertebroplasty needle. In contradistinction to the needle position in the bipediculate approach, where the tip of the needle enters the pedicle inferolateral to the superior articulating facet, the needle tip in the unipediculate approach enters the pedicle lateral to the superior articulating facet.
- Once the needle tip has passed through the pedicle switch to lateral fluoroscopy.
- The vertebroplasty needle is advanced into the pedicle under anteroposterior (AP) fluoroscopic control; the principle is to stay in the ring of the pedicle in anteroposterior view (AP-wiew) until the needle has reached the posterior wall of the vertebra in lateral view (L-view). Once the needle has reached the vertebral body, the procedure is continued under lateral fluoroscopy projection. The needle is advanced until it approaches the anterolateral wall in the midline (see movie, case 2). The needle tip is advanced as far forward as the junction of the middle one-third to one-fourth of the vertebral body at middle vertebral height (see Fig 2 to 4).

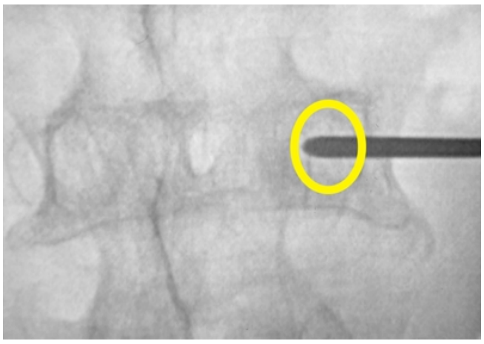


Fig. 1: "Stay in the ring" (the pedicle).

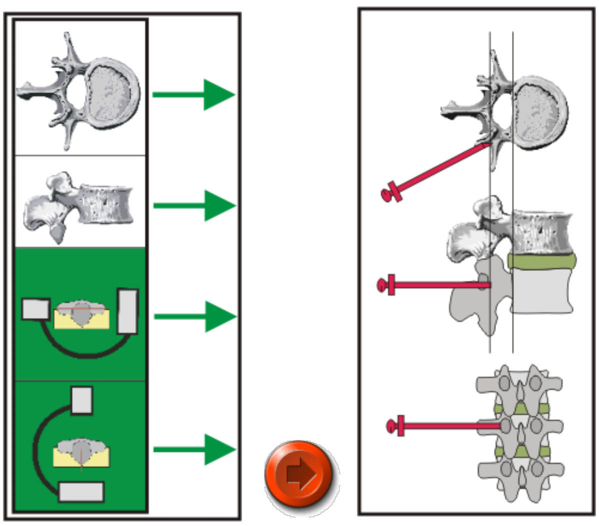


Fig. 2: The tandem technique. The appropriate fluoroscopic anteroposterior view for pedicular approach is a straight anteroposterior view, although some cases may require a 5°–10° angulation. The appropriate Lateral projection is a straight lateral view.

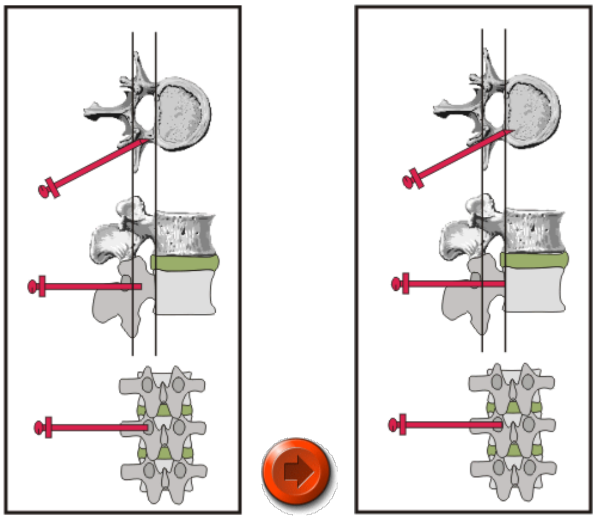


Fig. 3: The principle is to stay in the ring (the pedicle) in AP-view until the needle has reached the posterior wall of the vertebra in lateral projection.

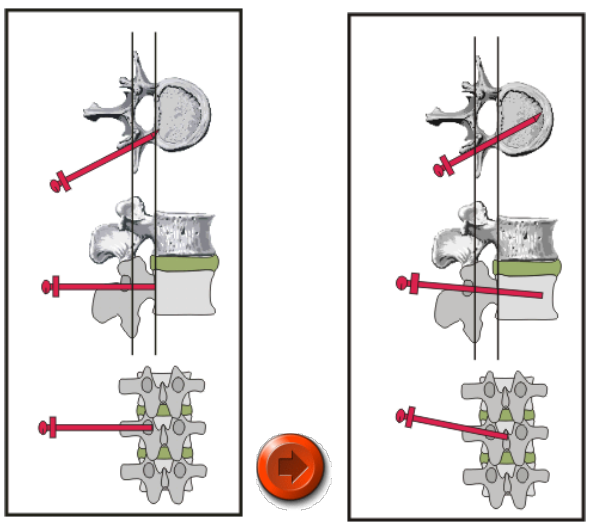


Fig. 4: Use the AP-view to ensure the needle tip is joining the midline of the vertebral body and at the same time use the L-view to ensure the needle tip is advanced as far forward as the junction of the middle one-third to one-fourth of the vertebral body at middle vertebral height.

Example 1

Lumbar Vertebroplasty: "stay in the ring" principle, needle course correction

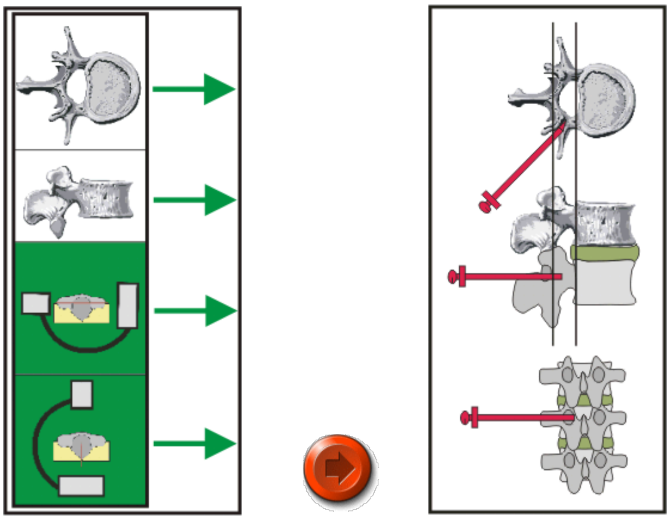


Fig. 1: The needle is placed with the hub notch in lateral position, (bevel face lateral) leading the course of the needle medially. Right: The needle is close to the internal limit of the ring (spinal canal) on AP-view; on L-view, the needle is still in the pedicle and has not reached the posterior wall. The course of the needle should be changed to avoid the spinal canal.

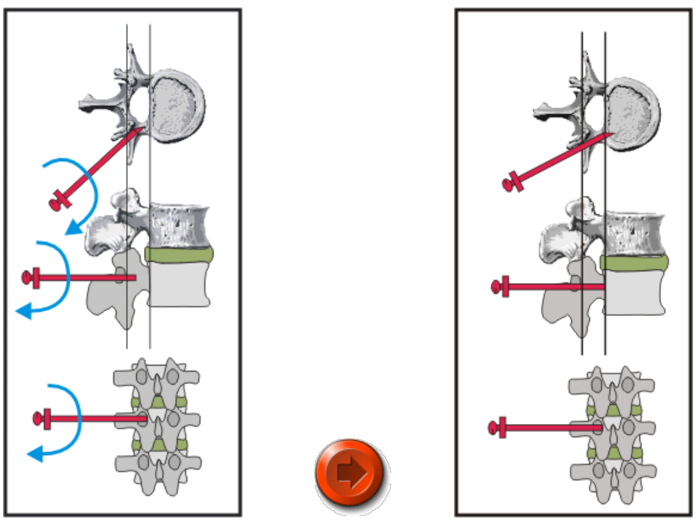


Fig. 2 Left: changing the bevel face direction by turning the connector 180°. The hub notch in medial position, bevel face in medial position leading the course of the needle to the opposite side.

Fig. 2 Right: The needle has reached the posterior wall of the vertebral body in lateral projection. The needle is still inside the ring on AP projection meaning that the neural structures (thecal sac, spinal cord) are avoided and the procedure can be continued under strict lateral fluoroscopy.

Example 2

Lumbar Vertebroplasty : "stay in the ring" principle, needle course correction

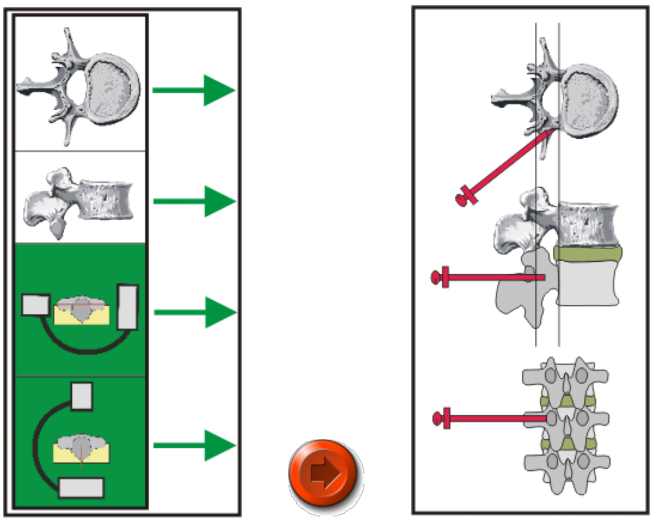


Fig. 1 Right: Needle too close to the external limit of the ring on AP-view while the posterior wall is not reached on lateral projection. The hub notch in medial position, (bevel face in lateral position) leading the needle to the side.

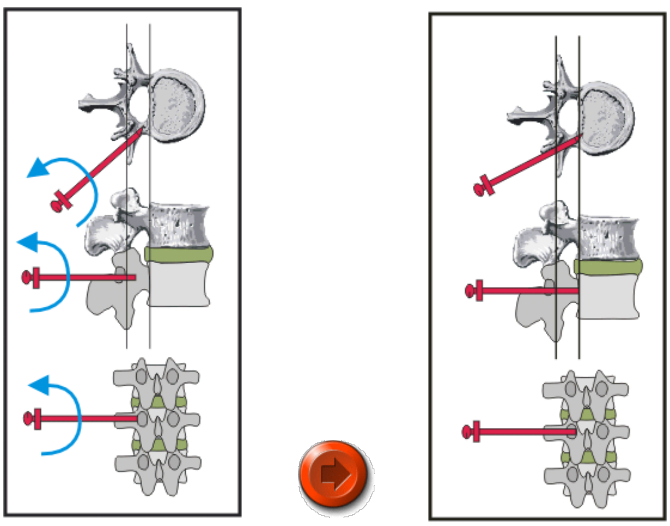


Fig. 2 Left: Changing the bevel face orientation by turning the connector 180°. The hub notch is in side position (bevel face in medial position) leading the course of the needle medially.
Fig. 2 Right: Hammering, course of needle corrected. The needle has reached the posterior wall of the vertebra body (lateral projection). Needle still inside the ring on AP projection the procedure can be continued under strict lateral fluoroscopy.

7) Technique : Cervical procedure

- For cervical procedures, anterolateral approach is recommended. Transoral approach can be used for C2.
- The cervical level can be approached without CT guidance under fluoroscopic monitoring. This procedure remains nevertheless difficult to perform under exclusive fluoroscopic guidance and unexperienced operators should use the more comfortable dual CT and fluoroscopy guidance.
- For exclusive fluoroscopic guidance, the patient is placed in supine position, with a cushion under the lower neck and the upper thoracic spine in order to hyperextend the neck. After preparation of the skin and local anesthesia, the needle is inserted anterolateraly.

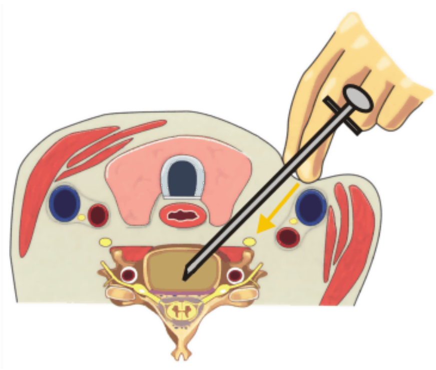
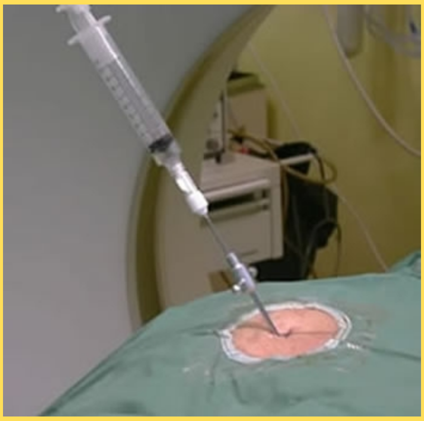
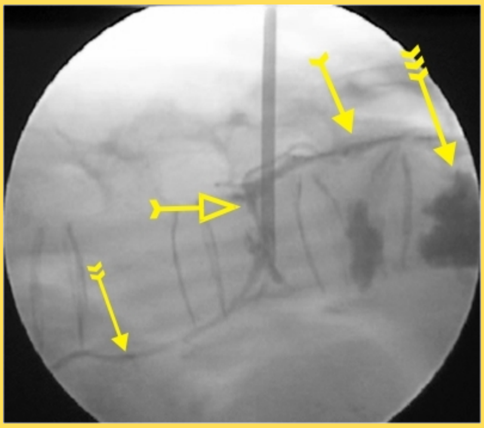


Fig. 1: For cervical procedures, anterolateral approach is recommended.

A15-gauge vertebroplasty needle is inserted anterolateraly. During the insertion, the trachea and esophagus should be pushed to remove them from the pathway. The carotid artery is detected by its pulsation and avoided.

8) Reminder : Biopsy , Phlebogram, Cement injection

Vertebroplasty procedure after needle placement		
1	Biopsy	
2	Phlebogram	
3	Cement preparation	
4	Cement injection	

9) Conclusion

Percutaneous vertebroplasty is usually performed under single-plane fluoroscopy guidance.

For novice operating physicians the procedure should be performed using biplane systems intially. Biplane fluoroscopic equipement facilitates the rapid aquisition of guidance information in two planes allowing to speed the procedure.

A combination of CT and fluoroscopy imaging provides an ever safer and easier guidance especially in very difficult cases. However, this type of expensive and cumbersome equipment is not commonly available in all departments.

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