Introduction

Both anterior and posterior minimal invasive surgical (MIS) techniques to the spine focus mainly on the lumbar region. However, these techniques have been used commonly in the treatment of cervical spinal disorders more recently. Spondylolisthesis, spondylosis, degenerative disc disease (DDD) as defined by neck and/or back pain of discogenic origin, degeneration of facets with instability, traumatic instability, pseudarthrosis, or failed previous fusion are commonly accepted indications. The MIS techniques are contra-indicated in the presence of active infection, osteoporotic bone, when conservative treatment is appropriate and with an inexperienced surgeon. Main advantages of MIS are the small skin incision, minimal muscle retraction, faster recovery, shorter length of stay and less economic loss. Narrow surgical corridor, increased neurovascular complications and inadequate neural decompression are disadvantages of the MIS techniques. New screws and equipment models, advanced in the neuromonitorization techniques, facilitate fixation technique and reduce the risk of complications. Today, we have few MIS techniques, which are easier to apply, more effective and safer than the previous techniques. Cervical percutaneous screwing could be classified as: posterior percutaneous transfacet screwing, posterior percutaneous pedicle screwing, posterior lateral mass screwing and percutaneous anterior odontoid screwing.

Methods:

Percutaneous Transfacet Screwing:

A single-level or multi-level anterior cervical disectomy with fusion, or supporting a strut graft are commonly used techniques for cervical spinal disorders. Compression is important for inducing fusion between two segments of the cervical spine. Percutaneous transfacet screws provide enough compression for fusion. Transfacet compression screws apply 45% more compression force than conventional lag screws and have a 24% greater pull out strength. The patient is positioned on a radiolucent operating room table in the prone position after the fixation of the head in a carbon Mayfield clamp under general or regional anesthesia. The surgical area is prepped and draped using sterile techniques and a midline 1 cm skin incision is made. The fluoroscope should be centered on the level of interest to minimize parallax effects. The right to left angulation should be adjusted to coincide with the lordotic curve of the cervical spine. The sagittal and mediolateral entry point is located at the center of the inferior articular process of the treated level. The wire introducer is inserted approximately 15° medially to obtain the ideal mediolateral trajectory, which should be directed towards the posterior tubercle or lateral of the foramen transversum. Once the entry
point and AP trajectory have been determined, the initial lateral trajectory should be perpendicular to the facet joint, up towards the cortical wall of the superior articular process. (figure 3) The wire introducer should be tapped and seated into the bone along the trajectory using the strike pin and a mallet. An AP view should be taken to assure that the needle is positioned correctly that there is no compromise of the nerve root or the spinal canal. The drill stop setting is adjusted 12mm by rotating the inner knob counter clockwise. Always start at 12 mm, and if necessary, we can use 14mm and 16 mm as well. The K-wire drill should not be advanced beyond the distal cortical wall of the superior articular process. (figure 4) After the desired depth is achieved, the wire introducer is removed and the K-wire stays in the hole. Extra care should pay to prevent migration of the K-wire. An 8-10 mm incision is made in the skin and fascia for a tubular retractor. The appropriate procedure for the selected tubular retractor is followed to allow access to the bone. The tap is driven into the bone until the tip reaches the appropriate depth the distal tip of the device targeted, which should be verified by fluoroscopy.
Care should be taken not to tap past the distal end of the K-wire. A facet compression screw is loaded onto the driver, passed over the K-wire and advanced into the bone to the appropriate depth by fluoroscopy to insure proper depth. The head of the collar should be left slightly proud so that compression of the facet joint may be obtained by using a compression tool. Lateral images should be used to confirm the compression of the device. After compression has been confirmed, the K-wire and retractor are removed. The same procedure should be repeated for the contralateral facet at the treated level.

**Percutaneous Transpedicular Screw:**
The patients are placed in prone position on a radiolucent table after the fixation of the head in a carbon Mayfield clamp. The cervical spine is maintained in a neutral position and the shoulders are taped caudal to obtain a clear intraoperative radiographic imaging of the lower cervical spine. Prior to the operation, the fluoroscopic image quality in AP, lateral, oblique and pedicle axis views is controlled. If the image quality is not sufficient, the percutaneous technique is abandoned. The skin entry point of the surgical approach is determined by positioning the spinal needles with a 40° convergence with the tip lateral to the estimated pedicle entrance lateral to the midline of the lateral mass in the true anterior–posterior fluoroscopic image. The position in cranial-caudal direction is chosen just beyond the extension to the upper endplate of the vertebra in lateral fluoroscopic view. Following the lordosis of the cervical spine, the meeting trajectory required for instrumentation of adjacent levels allowed the same skin and fascia incision. A skin and fascia

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**Figure 3:** The tip of the wire guide must be anchored into the inferior articular process. Sagittal route must be guided through the posterior trabecle by sagittal images.

**Figure 4:** Photograph demonstrating the placement, the route and the depth of the Kischner’s wire.
incision of 2–3 cm is sufficient for screw placement of 2 or 3 adjacent levels. Following muscles are split in fiber course until the entry point on the articular mass is identified. (figure 6) The correct screw entry point is marked after the placement of the trocar set using a bone awl. Therefore, the awl is positioned just below the lower margin of the upper articular surface and lateral of the midline of the articular mass. (figure 7) Using the lateral and oblique fluoroscopic view, the correct entry point and trajectory in

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**Figure 5:** Compression telescope and the Kischner wire are removed by gentle movements where compression facet screw is left behind.

**Figure 6:** Intraoperative AP and lateral fluoroscopic images showing the planning of the incision with the guidance wire.
the cranio-caudal direction is achieved. After opening the cortical wall, the awl is removed, with the trocar fixing the entry point and a drill bit for a 3.5 and 4.0 mm screw, respectively, with sleeve is inserted through the trocar and slow, automatic drilling is performed. The transverse angles of pedicles in the cervical spine average 40–50° in C3-C6 and 30–40° in C7 and C2. (figure 8) The additional rotation of the vertebra due to drilling is taken into account. The direction of the drilling trajectory is corrected according fluoroscopic oblique, lateral, true AP and pedicle axis view. Thereafter, tapping with

Figure 7: Intraoperative AP and oblique fluoroscopic images showing the insertion of the tubular retractor and the incision of the entrance point of the pedicle by awl.

Figure 8: Intraoperative AP and oblique fluoroscopic images showing the method of the drilling of the pedicle in proper angle and depth by using automated-drill.
a tap sleeve is performed and the screw is inserted. (figure 9) The screw length, as estimated on preoperative CT-scan, is controlled by lateral fluoroscopy. After the positioning of all the screws, the rods are inserted and fixed with blocker screws. The correct curve could be controlled by lateral fluoroscopy. Following muscles are split in fiber course until the entry point on the articular mass is identified. The correct screw entry point is marked after the placement of the trocar set using a bone awl.

**Percutaneous Lateral Mass Screw:**

The patients are placed in prone position on a radiolucent table after fixation of the head in a carbon Mayfield clamp. The cervical spine is maintained in a neutral position and the shoulders are taped caudal to obtain a clear intraoperative radiographic imaging of the lower cervical spine. Prior to the operation, the fluoroscopic image quality in AP lateral, oblique and pedicle axis views is controlled. If the image quality is not sufficient, the percutaneous technique is abandoned. The skin entry point of the surgical approach is determined by the use of spinal needles, which are parallel to the facet joint in lateral fluoroscopic image. The skin incision must be done 2 or 3 levels below the estimated level. The fascia incision is done near to the midline, bilaterally. Using the lateral and oblique fluoroscopic view, the correct entry point and trajectory in the cranio-caudal direction is achieved. Using the lateral and oblique fluoroscopic view, the correct entry point and trajectory in the cranio-caudal direction is achieved. 3.5 and 4.0 mm screws are inserted through the trocar. (figure 10)

**Percutaneous Anterior Odontoid Screw:**

All patients with displaced odontoid fractures undergo a reduction of the mal alignment using Gardner-Wells tong skull traction, and cervical lateral radiographs should be taken to confirm an anatomic reduction of the fracture. After fiber optic naso tracheal intubation, the patient is positioned supine with a small roll behind the shoulders to allow a slight extension of the neck. A radiolucent bite is placed in the patient’s mouth to facilitate the open-mouth view. The lateral masses of C1, the vertebral body of C2, and the odontoid process could be visualized under anterior/posterior and lateral fluoroscopy. Before attempting anterior odontoid screw fixation, the patient’s head is secured using Gardner-Wells

**Figure 9:** Intraoperative AP, lateral, and oblique fluoroscopic images showing the placement of the pedicle screw with 3.5cm diameter.
tongs with 2 kg of traction applied. Firstly, a 25–30 ml of NaCl % 0.9 is given from the cervical prevertebral fascia to the skin between the carotid sheath and the trachea and esophagus complex. An initial incision of 5 mm is made in the medial to the right sternocleidomastoid muscle, at approximately the level of the C4–5-disc space. The platysma is then divided, and the fascia of the sternocleidomastoid sharply incises along its medial border. Blunt dissection is used to arrive at the anterior border of the spinal column with the aid of a hemostat. Under the image intensifier control, a puncture needle, 1.2 mm in diameter, connected with a 10 ml syringe, is inserted into the potential space between the carotid sheath and trachea-oesophageal complex. A 1.2 mm K-wire with a blunt tip is then inserted into the puncture needle. The puncture needle is removed and the guide tube overpassed the K-wire. Blunt dissection is performed slightly within the avascular plane by using the guide tube and K-wire, then cephalad to the C2–3 disc space and extends to the prevertebral area. Under fluoroscopic control, the initial starting point for the guide tube is in the middle of the AP view, and is at the anterior aspect of the C2–C3 disc space of the lateral view to attain the proper angle. In this way, the entry point for the K-wire is allowed to be at the anterior inferior lip of C2. After the guide tube is anchored and the trajectory is deemed appropriate, the K-wire with the blunt tip is withdrawn and the guide tube is left in place. The sharp tipped K-wire is inserted through the guide tube until the pin reaches the entry point, and is then advanced into the odontoid distal fragment with a power-drill. The drilling path leads to the posterior superior tip of the odontoid process.

After the K-wire is positioned satisfactorily, the depth gauge determines the depth of penetration by the drill. Along the guide tube, a protection tube with a 6 mm outer diameter and 5.1 mm inner diameter is advanced, and the guide tube is subsequently taken out. The protection tube position is maintained throughout the operation to protect the soft tissues. (figure 11) Care must be taken to avoid advancing the K-wire further as the drilling is performed. A 3.5 mm self-tapping cannulated screw with partial threads is placed over the K-wire, inside the protection tube, and into the tip of the fragment. The screw length

Figure 10: Postoperative lateral and AP X-ray of the cervical spine showing the C3-4-5-6 lateral mass screws and bilateral rod construction performed by percutaneous posterior cervical fixation.
should be 1 or 2 mm shorter than the measure length if a gap between the fractured bone surface and the threads of the screw must cross the fracture line, because the lag effect derives only from the final tightening of the screw to increase compression and to approximate the fracture line. The wire and the tube are removed and the wound is checked for hemostasis. Flexion and extension of the patient’s neck is manipulated and spinal stability and screw placement is verified under fluoroscopy. (Figure 12) A single suture closes the incision.

Figure 11: Serial intraoperative fluoroscopic imaging showing the placement of the Kischner wire, penetration of the Kischner wire with automated drilling system into the odontoid through the odontoid tip.

Figure 12: Postoperative AP and lateral X-ray of the cervical spine showing the proper screw placement and adequate reduction.
Discussion

The decision for a particular internal fixation of the cervical spine should follow an analysis of the biomechanical stability, the type of neurologic compression, the underlying disease and the access morbidity. The anterior approach is often appropriate to achieve unrestricted spinal cord decompression and stabilization. However, there are indications, such as multilevel stabilization in neoplastic instabilities, post-surgical deformities, injuries of the cervicothoracic junction and multilevel corpectomies, which make a solely or additional posterior stabilization necessary. These posterior instrumentation procedures have been shown to be associated with increased postoperative complications. Similar to stabilization procedures of the thoracolumbar spine, which have been proposed to reduce access-related morbidity as muscular der-ervation, atrophy, length of hospital stay, blood loss and postoperative pain, minimally invasive procedures for posterior cervical instrumentation represent the next logical step. Therefore, several authors reported minimally invasive posterior procedures for stabilization and decompression of the cervical spine. However, the long-term benefit on clinical outcomes remains to be proven.

Percutaneous transfacet screwing is a easy technique to apply for subaxial stabilization of the cervical spine. Cervical devices were designed for transfacet compression, which immobilizes the facet joints at single or multiple levels in the cervical spine. The compression system does not require rod construction but fusion rate is insufficient.

The cervical pedicle screw fixation is the most rigid fixation method of the cervical spine. Despite its biomechanical advantages, the method is technically demanding and iatrogenic damage to neurovascular structures is feared. The main difficulty of the placement of pedicle screw is that landmarks are not clear. 12.5% of the screws were considered critical. For that reason, several authors advise the use of navigation and others stated that the use is relatively safe using a free-handed technique and the use of fluoroscopy if the surgeon is experienced and is familiar with the special anatomy of the cervical spine.

Lateral mass screws were first described by Roy-Camille and further modified and developed by Magerl. But, these traditional approaches required large midline incisions with stripping of the paraspinal muscles and resulted in significant postoperative neck pain. Percutaneous cervical screws are a novel surgical technique and are described by Wang et al. Using a small midline incision without excessive muscle dissection and muscle trauma, they can achieve single or multiple levels fixation with lateral mass screwing and rod construction. Lateral mass screw placements show low incidents (0–4%) of neurovascular complications. The most important disadvantage is that narrow trocars provide narrow surgical views, and inserting the rod is very difficult.

Kazan et al., first reported the anterior odontoid screw fixation technique. Immediate stability is achieved to the odontoid, thus decreasing the need for postoperative rigid external immobilization. And it is less surgically traumatic than posterior procedures. But the dissection, just like the common open procedures, needs extensive exposure, and care should be taken to avoid injuring adjacent nerves and blood vessels. The main advantage of this technique is its minimally invasive character and direct access to the target site that resembles the open procedure. This percutaneous procedure requires less dissection and exposure of normal tissue during the surgical approach, which can result in decreased blood loss, less postoperative pain and a much quicker recovery. The use of the new tube system may reduce the incidence of injury to the surrounding soft tissue, such as the esophagus, trachea, recurrent laryngeal nerve, and carotid artery. Careful patient selection is crucial to achieve successful odontoid screw fixation. Similar to the open procedure, we consider percutaneous odontoid screw fixation typically indicated in Type II and Shallow Type III fractures when the fracture line runs obliquely downward and backward or horizontal. It is contraindicated when the fracture line is downward and forward. In addition, some physical characteristics, such as short neck, significant cervical kyphosis, concomitant thoracic kyphosis, and barrel chest deformity, may interfere with the ideal screw trajectory.

Conclusion

The fluoroscopically assisted percutaneous cervical screw fixation methods are a technically feasible, safe, useful, and minimally invasive technique. Although there are several pitfalls with the procedure, careful preoperative planning and strict attention to properly selecting the insertion point, insertion angle and depth, with specially designed percutaneous
cannulated systems can make this percutaneous procedure effective and practicable.

Abstract

Minimal invasive surgical procedures are used commonly in treatment of a variety of spinal disorders. Cervical percutaneous screwing could be classified as: posterior percutaneous transfacet screwing, posterior percutaneous pedicle screwing, posterior lateral mass screwing and percutaneous anterior odontoid screwing. The most important advantages of the minimal invasive surgery are the small skin incision, minimal muscle retraction, faster recovery, shorter length of stay and less economic loss. The main aim of this study is to present percutaneous cervical screw techniques and evaluate their safety and efficacy in treatment of patients with cervical spinal disorders.

References