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Case study

Radiation exposure with hybrid image-guidance-based minimally invasive transforaminal lumbar interbody fusion

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ABSTRACT

The transforaminal lumbar interbody fusion (TLIF) is used for the treatment of back and leg pain secondary to spinal stenosis, degenerative disc disease, and spondylolisthesis. Minimally invasive surgery (MIS) is associated with less estimated blood loss (EBL), decreased length of stay, lower infection rates, and similar outcomes compared to the traditional TLIF. Fluoroscopy time has been reported with MIS-TLIF, but there are limited data on specific radiation dosages. We performed a retrospective analysis of a prospectively acquired cohort of patients undergoing MIS-TLIF. A total of 50 patients were included. Mean age was 53 years with 60% women and mean BMI of 30 (range 21–41). Diagnoses were as follows: 45 stenosis (90%), 29 spondylolisthesis (58%), 5 facet cysts (10%), 3 scoliosis (6%), and 1 cauda equina syndrome (2%). A single level was fused in 33 cases (66%), two levels in 15 (30%), three levels in 2 (4%). Average cage height was 10 mm with mean EBL of 80 ml and operative time of 240 min. The average radiation doses from intraoperative CT scan and fluoroscopy were 35.3 and 26.5 mGy, respectively. Average CT scan and fluoroscopy times were 5.2 and 37.1 s, respectively, for a total of 42.2 s. Average length of stay was 3 days (range 1–7 days). Although these data represent a preliminary experience, by streamlining the timing of intraoperative CT scan and minimizing the amount of intraoperative fluoroscopy, this protocol has the potential for decreasing operative time and radiation exposure.

1. Introduction

The minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is a well-utilized and popular technique for the treatment of lumbar degenerative disease [1–3]. Compared to the traditional open TLIF (O-TLIF), the MIS-TLIF is associated with decreased blood loss, narcotic use, and shorter hospital stay while resulting in similar patient-reported and radiographic outcome measures [4–10]. An often-cited disadvantage of this procedure is the need for increased fluoroscopy time and radiation exposure to both the patient and surgical team. There is a growing body of literature supporting the accuracy of pedicle screw placement using 3-dimensional computed tomography (CT)-based spinal navigation compared to traditional fluoroscopy [11–15].

In this study, we present our results in a cohort of adult patients who underwent MIS-TLIF with image-guidance-based pedicle screw placement followed by cage and rod placement confirmation with traditional fluoroscopy. This approach has the potential for decreased radiation exposure to both the patient and operating room staff; since the operating room staff generally leaves during the intraoperative CT scan, they are not subject to that component of the total radiation exposure. The use of image guidance also has the potential for shorter operative times by decreasing the time for pedicle screw placement. However, to take full advantage of this approach there must be readily available equipment and cooperation among operating room staff and radiation technologists.

2. Methods

2.1. Operative technique

The procedure is performed under general anesthesia with the patient positioned prone on the Jackson table with chest bolster and hip pads. After sterile preparation of the surgical area, a small stab incision is made over the posterior superior iliac spine (PSIS) contralateral to the side of the planned TLIF. The Stealth reference frame (Medtronic, Minneapolis, MN) is placed in the PSIS in a trajectory that places the reference arc inferior and medial to avoid interference with the standard trajectory of S1 pedicle screws

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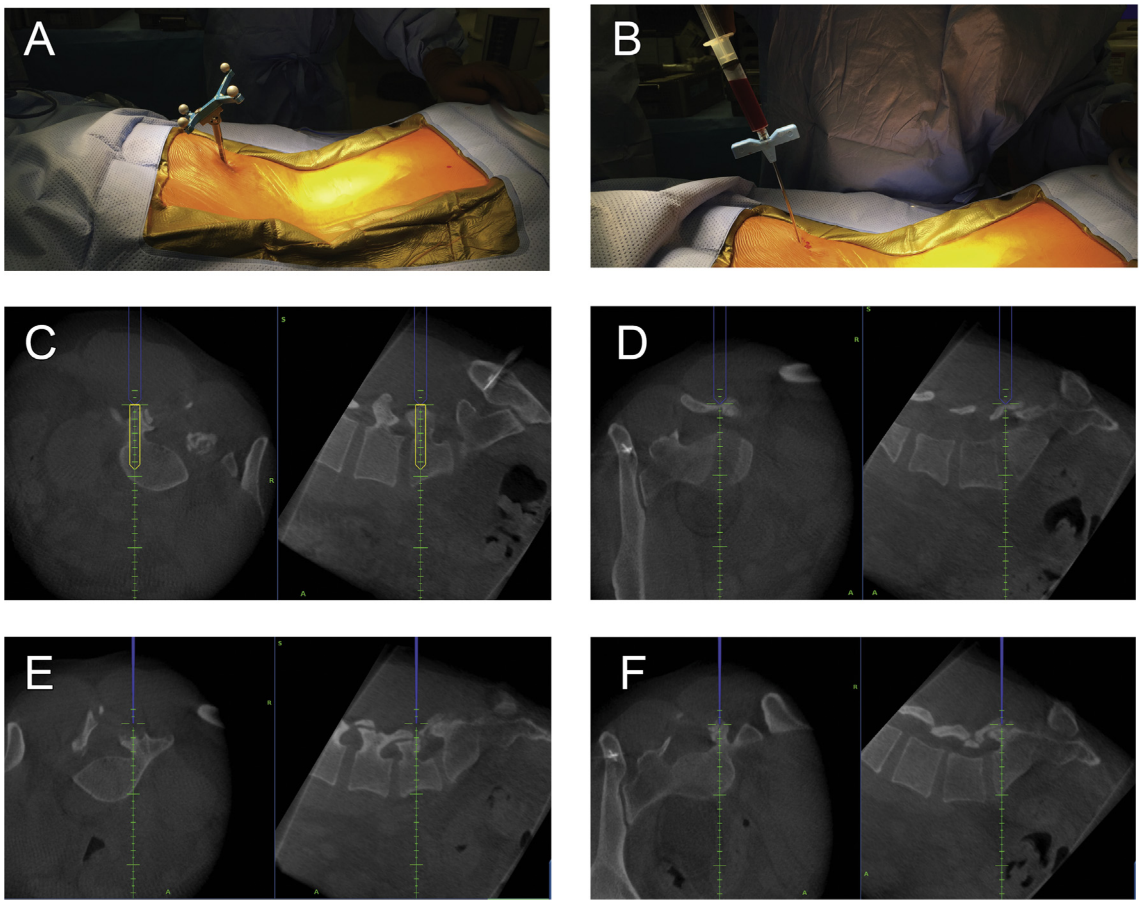

Fig. 1. Use of intraoperative navigation for MIS-TLIF. The Stealth reference frame is placed in the posterior superior iliac spine in a trajectory that places the arc inferior and medial to avoid interference with the standard trajectory of S1 pedicle screws (A). Prior to insertion of the reference frame, a Jamshidi needle is placed through the stab incision into the ilium to harvest bone marrow aspirate (B). Pedicle screw trajectories are planned using the Stealth system (C). The trajectory along the disc space is determined using the first tubular dilator which is navigated using the Stealth system (D). Navigation can be used to identify the location of the superior (E) and inferior (F) pedicle to maximize decompression without violating the pedicles.

(Fig. 1A). Prior to insertion of the reference frame, a Jamshidi needle can be placed through the stab incision into the ilium to harvest bone marrow aspirate (Fig. 1B). After intraoperative CT scan with the O-arm (Medtronic, Minneapolis, MN), pedicle screw trajectories are planned using the Stealth system (Fig. 1C); they are located 3.5 cm lateral to midline through 1 one inch incisions on each side (for single level fusion, 1.5 inch for two levels, and 1.75 inch for three levels). The navigated high-speed drill is used to cannulate the pedicles and K-wires are used to mark these trajectories. On the side opposite the TLIF, cannulated pedicle screws with reduction towers are placed over the k-wires.

For the discectomy and decompression, the trajectory along the disc space is determined using the first tubular dilator which is navigated using the Stealth system (Fig. 1D). Additional dilators are placed followed by the TLIF retractor, which is connected to a bed-mounted arm. The position of the retractor is confirmed by navigation. Laminotomy, flavectomy, and facetectomy are performed under the microscope. An added advantage is that navigation can be used to identify the location of the pedicles to maximize decompression while not violating the pedicles (Fig. 1D and E). If a contralateral decompression is indicated, the retractor can be angled across midline and the underside of the contralateral lamina removed as well as the ligamentum flavum and hypertrophic facet capsule. The trajectory along the disc space can be determined with navigation for the discectomy. After discectomy, the disc space is prepared with shavers and distractors. At this stage, intermittent fluoroscopy is used to visualize the amount of distraction and preservation of the end plates (Fig. 2A). The disc space is packed with allograft cellular bone matrix which can be mixed with autologous bone marrow aspirate harvested previously. The interbody device is inserted and confirmed by lateral and anterior-posterior (AP) fluoroscopy (Fig. 2B). Using the k-wires placed earlier, the remaining pedicle screws are placed on the side of the TLIF under navigation. A pre-bent rod is placed through the screw heads below the dorsal lumbar fascia. Periodic fluoroscopy is used during rod placement to confirm adequate overhang of the rod. Gentle compression is used to induce lordosis bilaterally and the rods are secured with locking caps. A final fluoroscopic image is obtained prior to closure. Patients ambulate on postoperative day 1 with a soft lumbar brace and obtain standing 36 inch x-rays prior to discharge (Fig. 2C).

2.2. Data collection

Patients were identified through a retrospective review of the senior author's case logs. Approval for all research activities was obtained through the UCSF Committee on Human Research, our institutional review board (CHR #17-21909). Patient demographics including age, gender, and presenting symptoms were collected from the medical record. Estimated blood loss, levels of surgery, and cage size were collected from operative reports. Radiation exposure (time and dose in mGy) was collected from reports generated by the radiation technologist after each case. Duration of each intraoperative CT scan is reported as the fluoroscopy time