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“Satellite pedicle screws” - A novel technique of pedicle screw insertion in obese patients undergoing lumbar fusion

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ABSTRACT

The presence of thick sub-cutaneous fat and bulky paraspinal musculature mandates extensive surgical dissection in obese patients undergoing open Transforaminal lumbar interbody fusion surgery. Securing a ‘converging’ pedicle screw trajectory becomes difficult by the counterforces of the erector spinae muscles and thick sub-cutaneous fat in obese patients, especially at the L5-S1 level. We describe the use of a limited standard posterior midline exposure and a separate, far lateral ‘satellite’ incision to insert pedicle screws in an optimal trajectory in obese patients. Through proper pre-operative planning of the axial and sagittal MRI, the appropriate entry site is determined which is executed intra-operatively to insert pedicle screws freehand. Through a single 1.5 cm incision, both L5-S1 screws were inserted. Fourteen obese patients (mean BMI was 30.5 ± 1.1) received 56 satellite pedicle screws for TLIF at L5-S1 level. The mean age was 48.3 ± 9.7 years. The mean blood loss was 244.8 ± 114 ml and the mean operative time was 126.7 ± 82.8 min. In all patients, the screws were inserted as per pre-operative planning without any difficulties. All wounds healed well without wound complications. There were no screw related complications, and in the antero-posterior and lateral radiographs, there were no screw breaches. Satellite free-hand pedicle screws are safe and easily reproducible. They enable limited dissection of the main surgical wound and well-medialised converging pedicle screws in obese patients.

1. Introduction

Obesity poses multiple intra-operative challenges during a spinal fusion surgery.[1] Apart from difficulties in anaesthesia and positioning, the length of a surgical incision is often longer in an obese patient to enable the surgeon reach the depths of the wound.[2] Open transforaminal lumbar interbody fusion is a commonly performed procedure and extensive dissection of sub-cutaneous fat and paraspinal muscles in obese patients becomes essential to direct the screws medially in a convergent manner.[1,3] An attempt to restrict the dimensions of the surgical wound deters the visibility of the surgeon and impedes him from creating an optimal screw entry and an ideal ‘converging’ screw trajectory. An exaggerated lumbar lordosis and the presence of hypertrophied multifidus muscle in muscular over-weight individuals further complicates the screw insertion experience. Higher incidence of pedicle screw malposition and the difficulties of attaining an intended pedicle screw trajectory in obese and overweight individuals has been well described in the literature.[4,5] While performing lumbar fusion in obese patients, it is always a bargain between having a longer incision with its attendant risks of wound healing problems, and a smaller incision with ensuing struggle and misplaced screws. While minimally invasive fusion techniques can limit the surgical dissection, the lack of universal availability and expertise and high cost in developing and under-developed countries, high radiation exposure and the poor visibility of bony structures in obese patients are concerns.[6]

To overcome these difficulties, we describe the use of a small, separate “satellite” incision for pedicle screw insertion as a novel attempt to ensure safety of pedicle screw insertion in obese patients.

2. Material and methods

This technique was applied in obese patients (BMI >30 and the presence of deep subcutaneous fat in the lumbar region > 5 cm thickness) undergoing open TLIF procedure at L5-S1 level. In such patients, the authors intended to reduce the extent of surgical dissection to expose only the laminae and the two facet joints on either side of the spinal segment being fused. The pedicle entry point is defined through the main surgical wound using a monopolar cautery at the junction of the transverse process and the lateral facet joint. Based on pre-operative planning, a small satellite skin incision is made approximately 6–7 cm away from

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the main surgical incision to initiate the pedicle screw entry and create the pedicle screw tract. This avoided the strong counterforces of the paraspinal muscles and sub-cutaneous fat. One incision can be used to insert screws at two adjacent levels.

2.1. Pre-operative planning (Fig. 1)

In the pre-operative axial MRI (Fig. 1A), at the chosen vertebral level, a line is drawn along the direction of the pedicle from the level of skin. The distance between this line and the midline is noted (Medio-lateral ML point). This was approximately 6 to 7 cms in most patients..

In the mid-sagittal MRI, a line is drawn from the skin surface along the pedicle trajectory of both the vertebrae to be included in the fusion zone (Cephalo-caudal CC point) (Fig. 1B). From this point, a perpendicular is dropped to the spine and the corresponding vertebral structure is noted. This helps to mark the CC point intra-operatively (Fig. 1C).

2.2. Operative technique

The patient was placed prone on bolsters on a radiolucent frame. A standard posterior midline exposure was performed to expose the spinal segment to be fused (L5-S1). Once the four facet joints have been exposed, the pedicle entry point is marked at the junction of the mid-transverse process and the lateral facet. At this stage, based on the pre-operative planning, a line was marked in the skin parallel to the surgical incision six to seven centimetres away from it (Fig. 2A). This would be the appropriate medio-lateral trajectory. A 1.5 cm incision was made in this line, at a point that would correspond to the CC point (Fig. 2B). This CC point was marked using the C arm image as shown in Fig. 1C. This would provide the optimal cephalo-caudal and medio-lateral screw trajectory, without the impediment of the deep fat and muscles.

The stab incision was deepened till the deep fascia and the fascial incision was made slightly longer so that both L5 and S1 screws can be inserted through the same skin incision. A pedicle entry awl was passed towards the spine. In the main wound, a Hohmann's elevator or deep Langenbeck retractor was used to gently retract the muscles to look for the appearance of the tip of the awl from the paraspinal muscles. Once noticed, it is guided towards the previously marked pedicle entry point. Through a free hand technique, a pilot hole was created, and felt with a feeler passed through the satellite hole (Fig. 3A). A straight pedicle probe was then inserted in the same direction to guide it through the pedicle into the vertebral body (Fig. 3B). The track was tapped and felt with a feeler again, and the appropriate pedicle screw was inserted (Fig. 3C). The same incision can be used to insert the subjacent S1 screw also, with minor adjustments in cephalo-caudal angulation. With this technique, there was no undue resistance from the thick paraspinal structures of the obese patients. There was no need for extensive dissection either cranio-caudally, laterally or deeper, which would increase bleeding, prolong the surgical time and pose a higher risk of wound complications (see Fig. 4).

Similarly, screws can be placed on the opposite side (Fig. 3D). A unilateral rod was persuaded through the main surgical wound. Since these are poly-axial screw heads, insertion of screw caps and rod was conveniently performed through the main incision. The use of a tissue-protecting spatula ensured the smooth passage of the rods through the

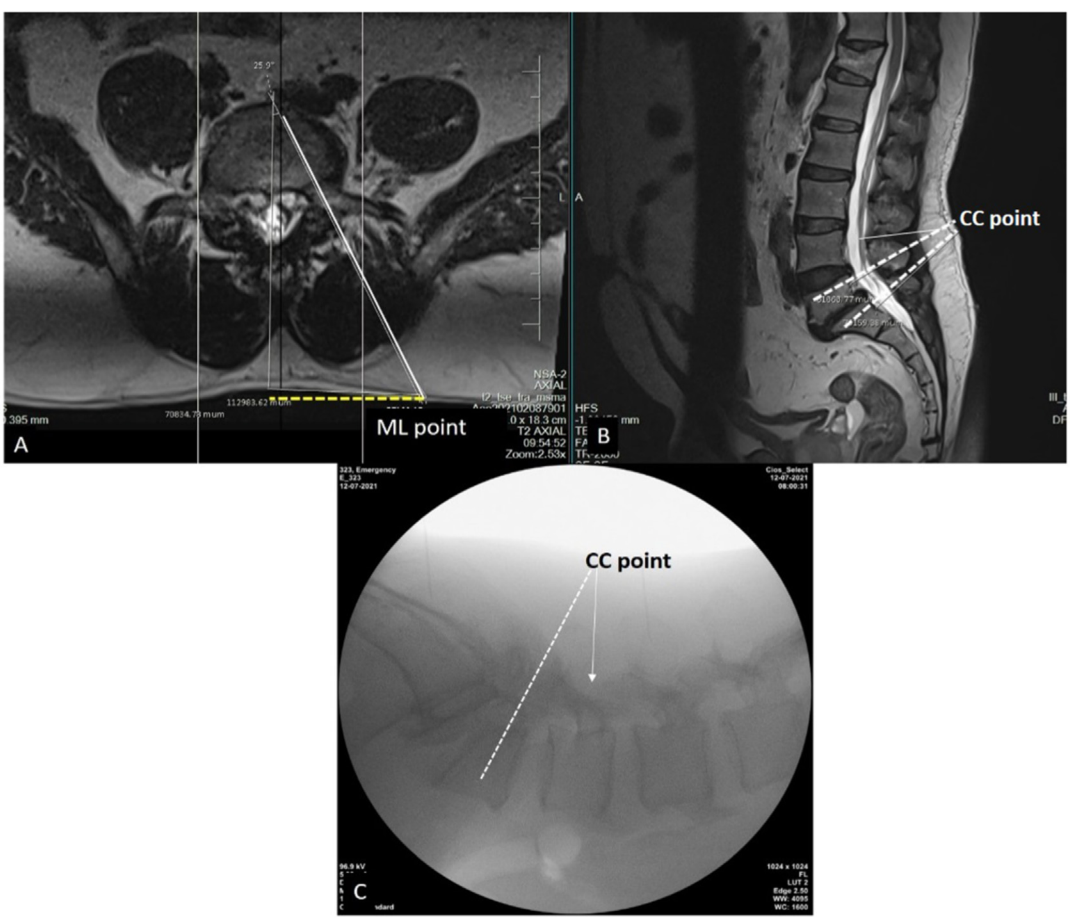

Fig. 1. Pre-operative planning to identify the optimal zone of satellite pedicle screw entry. A: In the axial MRI, a line is drawn (solid white) along the pedicle trajectory from the skin. This is the Medio-lateral point. The distance from the midline to this point is measured (yellow line), B: In the sagittal MRI, a line is drawn (dotted white) along the pedicle from the skin surface (Cephalo-caudal point). C: A perpendicular dropped from CC point helps to identify this point intra-operatively. In this case, it is close to L4 pedicle. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

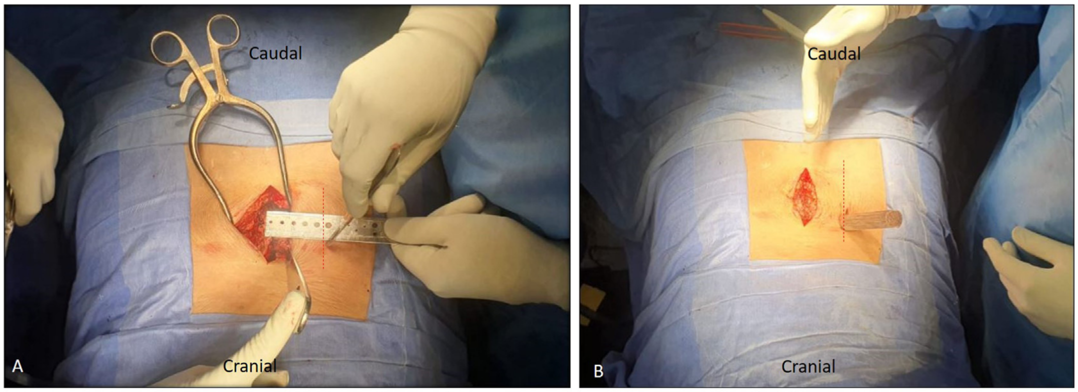

Fig. 2. Intra-operative picture to make the satellite incision. A: A line is drawn parallel to the skin incision at a distance determined using Fig. 1A. B: A 1.5 cm incision is made in this line at a point corresponding to the CC point.

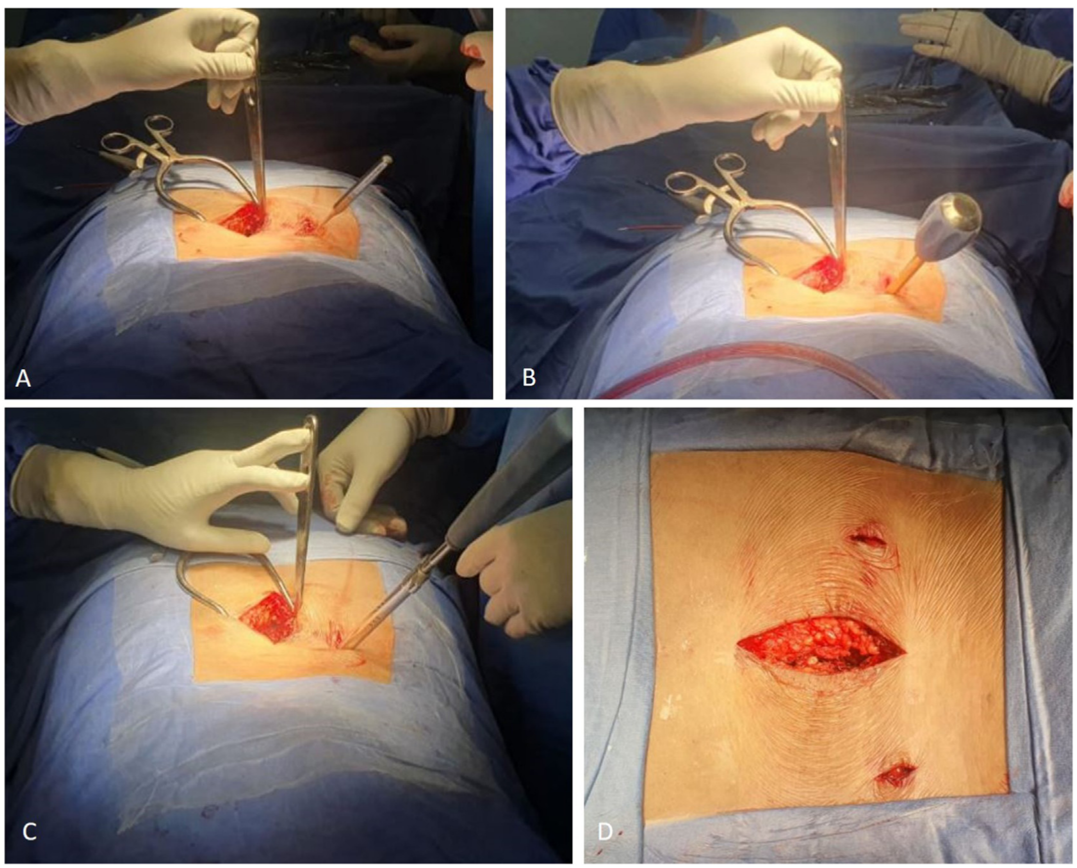

Fig. 3. Intraoperative pictures showing the pedicle feeler passed through the satellite incision (A), followed by the insertion of pedicle probe (B), pedicle screw (C). Note the optimal converging trajectory of the screws. Through one incision, two adjacent screws can be inserted. D: Final image showing the optimal surgical incision and two lateral satellite incisions for bilateral screw insertion.

main incision. At the L5-S1 level, the poly-axial screw heads are close to each other and rod insertion was not difficult. The interbody fusion was performed through the main incision. At the end of the procedure, the contralateral rod was placed. The wounds were closed in layers. The satellite incision was closed in a single layer. The post-operative protocol was similar to any TLIF surgery.

In the last three years, the authors had performed this technique in 14 obese patients whom underwent TLIF at L5-S1 level. Though this technique can be applied at other levels, its maximum utility was noted at the L5-S1 level because of the thick fat and steep lordotic angulation, which typically made conventional screw insertion difficult in obese patients.

3. Results

The mean age of the patients was 48.3 ± 9.7 years. The mean BMI was 30.5 ± 1.1. All fusions were performed at the L5-S1 level. The diagnosis included lytic spondylolisthesis (n = 6), degenerative spondylolisthesis (n = 3), dysplastic spondylolisthesis (n = 2), recurrent disc herniation (n = 3). Males were predominant (n = 12) and females were two in number. The mean blood loss was 244.68 ± 123 ml and the mean operative time was 126.5 ± 36.5 min. In all patients, the pre-operative planning could be executed without any difficulties. A surgical drain was not used in any of the patients. All wounds healed well with primary

Fig. 4. Intra-operative C arm pictures show the well medialised pedicle screws in an obese patient. Axial CT images show the direction of screws through the satellite entry.

intention. There were no screw related complications and in the antero-posterior and lateral radiographs, there were no screw breaches. The technique had an easy learning curve and well reproducible intraoperatively.

4. Discussion

We have described the use of a separate incision to insert pedicle screws in obese patients ('satellite' pedicle screws), which has not been described before. Obesity is considered as a difficult scenario for safe pedicle screw insertion in many studies.[4,7,8] Often, in an effort to visualise the landmarks for pedicle screw insertion, the surgeon uses a longer incision in obese patients.[1,7] The extent of sub-periosteal dissection over the unfused proximal and distal levels is also more in obese patients. A longer incision and extensive dissection are also essential in fat individuals to angulate the screws medially in a converging trajectory.[4] A limited incision in obese patients makes the lateralising counterforces of the paraspinal muscles and thick subcutaneous fat stronger, thus leading to a straight screw trajectory. Such screws can have a weaker biomechanical strength compared to medially converging screws.[9] The use of bigger incision and deeper dissection is associated with potential complications including increased blood loss, longer surgical time, more post-operative pain, extensive fibrosis and higher chances of wound infection and wound healing complications.[10]

To avoid such complications, a smaller surgical incision along with separate tracks for pedicle screw insertion would be beneficial. In our case series, we noted that with appropriate pre-operative planning, the screws could be inserted comfortably without risks of medial or lateral breach. The technique was also reproducible as per pre-operative planning in all the fourteen patients. The limited incision also enabled us to avoid the use of surgical drains. At a minimum of one year follow-up, none of the patients had wound infection or wound complications, presumably by the advantages incurred by limited dissection.

The use of central incision for decompression and separate percutaneous pedicle screw entry using image guidance has been described previously (Hybrid PLIF).[11] In their study, the authors suggested that this technique allowed minimization of muscular dissection, thus reducing morbidity, less requirements for postoperative pain medication and allowed earlier mobilization with reduced risks of infection whilst providing effective decompression and stabilization of the degenerative motion segment. Our satellite pedicle screw technique works along similar principles and is especially effective in obese muscular individuals.

With increasing use of minimally invasive techniques, MIS-TLIF is useful in obese patients to avoid risks of wound infection, and achieve optimal screw paths.[12] However, imaging in obese patients can be difficult because of the thick sub-cutaneous fat warranting multiple images to acquire optimum screw fixation. Further in obese patients requiring central and bilateral neural decompression, a minimally invasive over-the-top decompression can be difficult. Our technique avoided radiation risks since the screws are inserted free-hand without the need for image intensifier. It also enabled adequate decompression of neural structures through the main incision. The technique can be learnt in cadaver models and non-obese patients so that it can applied with ease in obese patients. The key point is to perform a thorough pre-operative planning and eyeballing the pedicle trajectory while creating the track. The limitations of the study include its small case series, retrospective nature and lack of validation. This technical note would enable surgeons routinely performing open TLIF, to insert well-converging screws with limited dissection in obese patients. Further, comparative studies between open TLIF using 'satellite' screws and standard TLIF techniques would shed more light on the advantages reaped by this technique. For surgeons well-versed in MIS techniques, this technique would be of value in cases where there is a severe stenosis and bilateral neural compression.

In conclusion, 'satellite' pedicle screws are a safe method to insert pedicle screws in the appropriate converging trajectory in obese patients obviating the need for long incisions and extensive dissection.

Credit author statement

RMK: Conceptualisation; Methodology; Formal analysis, **APS**: Surgical Inputs; Ideas; Writing, **SR**: Guidance; Editing.

Declaration of competing interest

Please find attached our submission to the World Neurosurgery journal.

I, Rishi Mugesh Kanna, state that there are no conflicts of interest and the authors have nothing to disclose with regards to the attached submission.

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Abbreviations

BMI: Body Mass Index
CC: Cephalo caudal
ML: Medio lateral
MRI: Magnetic Resonance Imaging
MIS: Minimally Invasive Surgery
TLIF: Transforaminal Lumbar Interbody Fusion