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Original article

Cortical Bone Trajectory Versus Pedicle Screw Techniques for Dorso-Lumbar Fixation

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Abstract:

Background: Posterior spine screw fixation to allow bony fusion is a common and reliable method of instrumentation of the spine for a variety of spine pathologies. The mainstay of this kind of surgery has been the use of pedicle screw fixation, traversing the pedicle down its anatomical axis with cancellous screw. The aim of this study is to evaluate and compare the outcome of cortical bone trajectory technique to the pedicle screw technique in dorso-lumbar fixation. **Patients and methods:** Forty patients with different lumbar pathologies were categorized into 2 groups: (Group A) includes 20 patients who operated with cortical bone trajectory technique (follow-up range 6-18months) and (Group B) includes 20 patients operated with pedicle screw technique (follow up range 6-20months). **Results:** The mean VAS score improved significantly from 7.3 before surgery to 2.9 at the latest follow-up in group (A) and from 8 before surgery to 3.1 at the latest follow-up in group (B). VAS and ODI outcomes were comparable in both groups. The mean operative time was 130 minutes in group (A), and 140 in group (B). Solid bony fusion was achieved in18 patients (90%) in group (A) and in 17 patients (85%) in group (B), it does not differ regards the fusion rate with the pedicle screw.
Conclusions: Results of CBT were good, and complications were few with no significant different to pedicle screw fixation. Cortical bone trajectory takes advantage of a cortically based track through the pedicle, which may result in improved fixation strength compared with a traditionally placed pedicle screw in certain indications. The technique was initially advised for osteoporotic patients. Complications with this new technology have been low and excellent fusion rates.

Keywords: cortical bone trajectory, pedicle screw technique, radiological outcome, clinical outcome.

Introduction

Posterior spine screw fixation to allow bony fusion is a common and reliable method of instrumentation of the spine for a variety of spine pathologies. The mainstay of this kind of surgery has been the use of pedicle screw fixation, traversing the pedicle down its anatomical axis with cancellous screw (1).

In 2009, Santoni et al., introduced a novel screw trajectory called cortical bone trajectory technique (CBT). They thought that it will improve initial fixation by optimizing contact of the screw with the cortical bone of the vertebrae and increased cortical bone contact providing enhanced screw grip and interface strength in certain indications (2).

CBT starting point is on the medial aspect of the pars, with angulation of screw in a mediolateral and caudocranial direction under fluoroscopy to confirm the correct angulation. Performing this step with drill- not a pedicle probe- is mandatory due to risk of fracture of the pars. The drill should be advanced under fluoroscopy to avoid breaching the superior endplate, then tap the track as the same size as the planed screw (3).

Since the introduction of CBT, a number of morphometric and biomechanical studies have been done and support its viability for fixation, most of them citing no significant bio-mechanic difference. But there is a significant difference in contact bone density for CBT screw and has superior fixation strength when compared to pedicle screw (4).

The aim of this prospective study is to evaluate and compare the outcome of cortical bone trajectory technique to the pedicle screw technique in dorso-lumbar fixation.

Patients and Methods

This comparative study had performed at the Neurosurgery department, at Banha University hospitals and Al -Azhar teaching hospital, starting April 2020 till March 2022. Forty patients- with different lumbar pathologies- were categorized into 2 groups (Group A) includes 20 patients operated with CBT and (Group B) includes; 20 patients operated with PS (Table 1).

Inclusion criteria

1) Patients of different lumbar pathologies including degenerative spondylolisthesis, adjacent segment lumbar disease, failed pedicle screw, fixation of osteoporotic patient.
2) Patient age above 50years old.
3) Both sexes were included.
5) General fitness for surgery was considered.
6) The affected spinal levels between 10^{th} Thoracic vertebrae till 5^{th} lumbar vertebrae (T10-L5).

Exclusion criteria

1) Presence of discitis/osteomyelitis or sepsis (active infection).
2) Fracture pars.
3) Severe systemic illness and unfitness for surgery.

The approval number of the local ethical committee: 00056.

Pre-operative Clinical and Radiological Evaluations

Patients were assessed as regards to full medical history including name, age, sex, occupation, residency, martial statue, special habits, complaint (back pain, weakness, numbness, sphincters, sexual potency and gait) and history of any systemic illness or previous thoracolumbar spine surgery. Systemic examination. *Local examination includes* scar for previous back surgeries, site of pain, local tenderness over spinous process and neurological examination (motor, sensory, reflexes). Preoperatively clinical assessment of pain severity using the Visual Analogue Scale (VAS). General laboratory investigations were done.

Radiological assessment: by using Plain X-ray (AP view, Lateral view and Dynamic view) to assess pars interarticularis and vertebral instability. CT scan (Axial view and sagittal reconstruction) to assess bony part of the spine. MRI scan (Axial view and sagittal view) to assess the spinal cord and intervertebral discs. DEXA scan measure bone mineral density.

Table (1): Demographic characteristics of the 2 studied groups.

Item	Group (A)	Number	%	Group (B)	Number	%
Number	**20**			**20**		
Sex	Male	8	40%	Male	9	45%
	Female	12	60%	Female	11	55%
Age range yrs(mean± SD)	50-70y (62±3.6)			45-65y (55±4.2)		
Type of pathology	degenerative spondylolisthesis	8	40%	adjacent segment lumbar disease	6	30%
				fixation of osteoporotic patient	4	(20%)
	adjacent segment lumbar disease	4	20%			
				degenerative spondylolisthesis	10	(50%)
	failed pedicle screw	1	5%			
	fixation of osteoporotic patient	7	35%			
Site of spinal pathology	L2-3	4	20%	L2-3	2	10%
	L3-4	10	50%	L3-4	3	15%
	L4-5	6	30%	L4-5	7	35%
	L5-S1	0	0	L5-S1	8	40%
Level of operation	One level	14	70%	One level	12	(60%)
	Double level	6	30%	Double level	8	(40%)
Symptoms	Low back pain	20	100%	Low back pain	20	(100%)
	Sciatica	16	80%	Sciatica	17	(85%)
	Neurogenic claudication	16	80%	Neurogenic claudication	16	(80%)
	Motor deficit	1	5%	Motor deficit	0	0
	Sphincter dysfunction	4	20%	Sphincter dysfunction	3	15%
Symptoms duration range (Mean ± SD)	(5 – 30m) (9.97± 5.87)			(6 -30m) (9.87± 5.87)		

Operative Techniques

In CBT group, midline skin incision is made centered over the involved segment from the superior endplate of the upper instrumented vertebrae to the inferior endplate of the lower instrumented vertebrae with less lateral soft tissue dissection limited to facet joints, so, the incision is smaller than pedicle screw technique. In PS group, dissection of para-spinal muscles and facet joints to insert the traditional PS.

Cortical Bone Trajectory Fixation

The entry point is defined on the medial aspect of the pars at the junction of the center of the superior articular process and a line 1 mm inferior to the inferior border of the transverse process. An awl is introduced followed by drill with the 3.0-mm drill bit is then used to develop the screw tract. The drill is directed from the entry point approximately 20°- 25° cephalad and 8°- 10° laterally. The ideally placed CBT screw makes contact with cortical bone at four points (lateral part of the lamina, lower part of the pedicle, posterior lateral part of the vertebral body and the sub endplate cortical bone)- all of which have high bone mineral density (BMD). The trajectory is palpated with a sound probe to palpate the created tunnel and feel the breach of the lateral aspect of the vertebral body wall, tap the track as the same size as the planed screw followed by the appropriate sized screw. Intraoperative fluoroscopy is used to monitor appropriateness of the screw trajectory. The rest of screws are not placed until interbody fusion completed, because of disc space may be impeded by the limited exposure and the screw head. This may be a potential disadvantage of cortical screws compared to traditional pedicle screws (Figures 1-2).

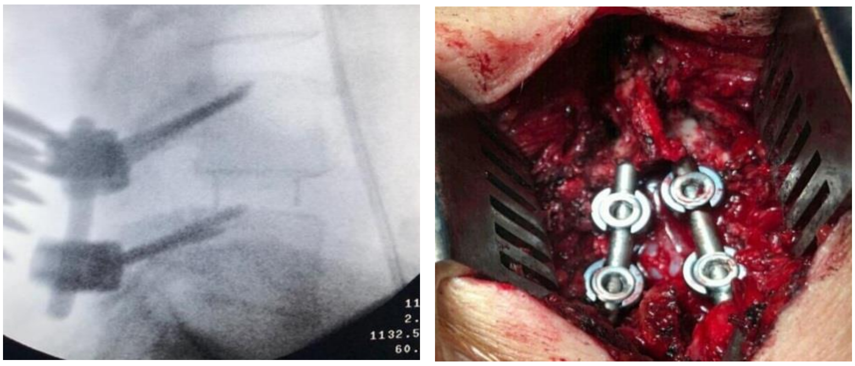

Fig. 1: **Intra-operative** illustration of L4_5 cortical bone trajectory fixation showing limited exposure of spinal canal after screws placement

Fig. 2: **Intra-operative** illustration of L3_4_5 cortical bone trajectory fixation with spinolaminar decompression.

Postoperative Clinical and Radiological Evaluation:

Clinical assessment of pain severity using the Visual Analogue Scale (VAS) before discharge and in follow up visits till12 months after surgery in 39 (95%) patients and Oswestry Disability Index (ODI) to measure patient's activity and permanent functional disability.

Plain X-ray (AP and Lateral view), were performed for all patients before discharge to confirm the correct location of the hardware. CT were performed in CBT group to evaluate correct screw placement that was close (±3 mm) to the disc endplate or the lateral border of the vertebra. Long-term radiological control was performed at 12 months after surgery in 36 (90%) patients. Computed tomography (CT) and dynamic flexion-extension X-ray images of the lumbar spine- were performed to assess spine stability, mobility of the fused level, bony union, and signs of haloing of the screws. In the follow-up, CT and MRI were also performed in patients of significant ongoing pain to diagnose complication.

Statistical Analysis

The data collected were analyzed using the Statistical Program for Social Sciences (SPSS) 22.0 software 302 for Windows by a professional statistician.

The following tests were done.

- Mean
- Standard deviation
- Range
- Student t test for independent samples
- Fisher's exact test
- Person's correlation coefficient (r)
- Chi square test (χ^2):

Probability of error (P value) used to indicate level of significance: Values are considered significant when the p value is less than 5% ($p<0.05$), highly significant when the p value is less than 0.1% ($p<0.001$) and non-significant when the probability of error is more than 5% ($p>0.05$).

Results

Clinical Outcome:

The mean VAS score improved significantly (from 7.3 to 2.9) at the latest follow-up in group (A) and (from 8 to 3.1) at the latest follow-up in group (B), The mean ODI improved (from 40.8% to 8.7%) in group (A) and (from 42 %to12.1%) in group (B) at the latest follow-up p values…? (Table 2). No significant differences were found in the VAS scores or ODI between the 2 groups ($p>0.05$).

The mean operative time was (130±15 minutes) in group (A) and (140±12.5 minutes) in group(B), with no significant difference between both groups ($p>0.05$). In group(A), the mean intra-operative blood loss was (600±30 ml) and in group(B), was (650±20 ml). The mean blood loss was less in group(A) than in group(B), although, we found no significant difference between both groups ($p>0.05$). The difference between the two groups according to mean hospital stay was not significantly different ($p>0.05$) with a mean recovery duration of (2.2±0.7 day) for group (A) and (2.5±0.73 day) for group (B) (Table 3).

Radiological Outcome:

Fusion was evidenced by bone bridge formation between the vertebral bodies in 18 of 20 patients (90%) in group (A) and in 17 of 20 patients (85%) in group (B) (Table 4). The difference in fusion rate was not significant ($p>0.05$).

Table (2): Clinical outcomes in the 2 studied groups.

Item	Group (A)	Group (B)
Pre- OP mean VAS ±SD	7.3±0.9	8±0.8
Post OP mean VAS ±SD	2.9±0.4	3.1±0.5
Pre- OP mean ODI ±SD	40.8±1.9	42±2.7
Post OP mean ODI ±SD	8.7±0.9	12.1±1.2
P-value	p>0.05	

Table (3): Operative Findings in the 2 studied groups.

Item	group(A)	group(B)	P value
Mean OP time (min) ±SD	130±15	140±12.5	p>0.05
Mean intra OP Bl. loss (ml) ±SD	600±30	650±20	p>0.05
Mean hospital stay (days) ±SD	2.2±0.7	2.5±0.73	p>0.05

Surgery-related Complications:

Post-operative superficial wound infection was encountered in only one patient (5%) in group (A) and 1patient in group (B). Dural tear occurred in 2 patients in each group (2 patients (10%) in group (A) and 2 patients (10%) in group(B)). Symptomatic ASD developed in only one patient (5%) from the group (A) who improved with conservative treatment. In group (B), one patient (5%) developed symptomatic ASD (lumbar spinal canal stenosis at the segments adjacent to the fused area) after 10 to 14 months and improved with conservative treatment. There were 2 patients (10%) of screw malposition. In group (A) and in group(B), 2 patients (10%) had malposition screws need no revision and one (5%) patient experienced screw loosening, had a diagnosis of osteoporosis and was transferred to the CBT (Table 5).

Table (4): fusion status in the 2studied groups

Item	group(A)		group(B)		P value
Fusion	Union	18 (90%)	Union	17 (85%)	p>0.05
	Non-Union	2 (10%)	Non-Union	3 (15%)	

Table (5): Surgery related complications in the 2 studied groups.

Item	group(A)		group(B)		P value
Complications	Superficial wound infection	1(5%)	Superficial wound infection	1 (5%)	
	Screw malposition	2(10%)	Screw loosening or malposition	3(15%)	p>0.05
	Dural tear	2(10%)	Dural tear	2(10%)	
	Adjacent segment disease	1 (5%)	Adjacent segment disease	1 (5%)	

Case presentation: (Figures 3-4).

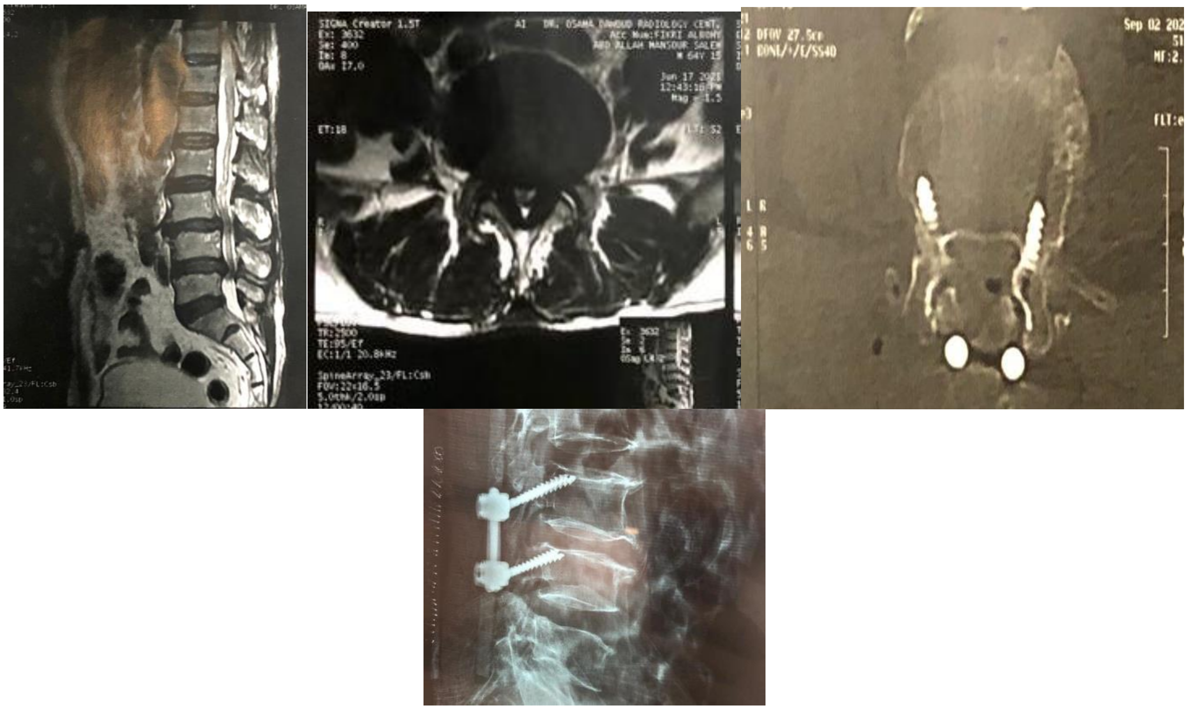

Fig. 3: preoperative MRI and postoperative CT scan and plain radiogram of L3-4 fixed by CBT.

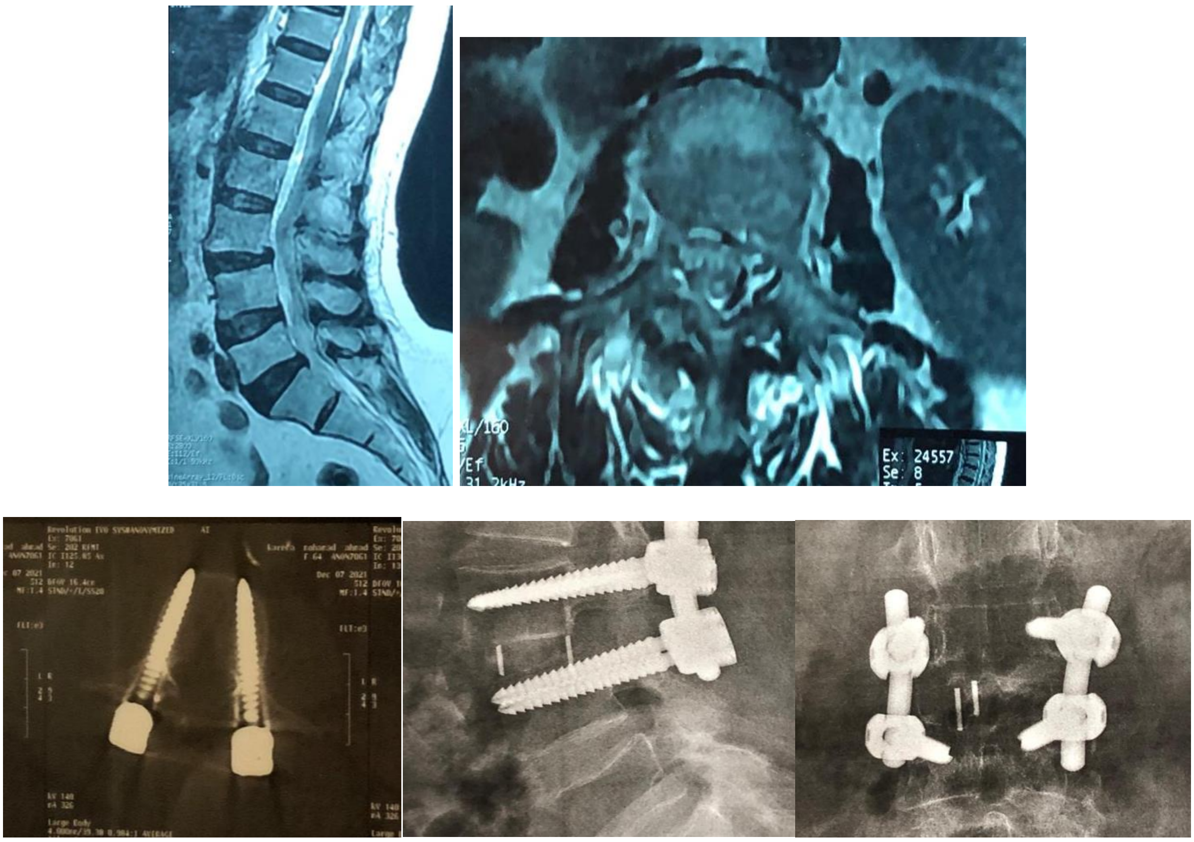

Fig. 4: preoperative MRI and postoperative CT scan and plain radiogram of L3-4 fixed by traditional pedicle screws and interbody cage.

Discussion

Santoni et al. (2) proposed a new pedicle screw trajectory and called it the cortical bone track. A number of morphometric and biomechanical studies were done - to evaluate the CBT viability for fixation- most of them citing no significant biomechanical difference. But, there is still a significant difference in contact bone density after surgery using CBT screw and it has superior fixation strength- when compared to pedicle screw- which has significant implications on stability for lumbar spine surgeries in elderly patients (5).

Cortical bone trajectory has gained popularity as a minimally invasive spine surgery in recent years. The main advantage of CBT is that foramina decompression of the spinal canal, discectomy, interbody fusion, and screw fixation- can be performed with only small incision. In general, the advantages of minimally invasive spine surgery are less tissue damage, reduced morbidity, faster functional recovery, and the ability to achieve the same surgical goal, compared to traditional surgical methods (6).

Both CBT and PS provided significant improvement in pain relief and functional status in our study. The mean VAS score improved from (7.3 to 2.9) in CBT group and (from 8 to 3.1) in PS group. The mean ODI (from 40.8 to 8.7) in CBT group and (from 42 to12.1) in PS group at the latest follow-up, were similar to those reported in other studies that had 2 or more years of follow-up (7-8). Chin et al. described 30 patients with an average follow-up of 2 years. They reported improvements in the mean visual analogue scale (VAS) for back pain (from 7.8 to 2.5), in the mean VAS for leg pain (from 4.2 to 0.2), and in the mean ODI (from 40.8 to 28.7) (7). In a series of 35 patients, Lee and colleagues showed improvements in the mean VAS for back pain (from 7.7 to 2.7), the mean VAS for leg pain (from 5.9 to 1.3), and the mean ODI (from 35.1 to 11.8) (8). In our study CBT group had no significant difference with PS group in operative time (130 min vs. 140 min), intra-operative blood loss was (600 ml vs. 650 ml), or hospital stay (2.2 day vs. 2.5 day). In a retrospective comparative study of 16 CBT versus 19 traditional screws in open posterior lumbar interbody fusions for single-level lumbar spondylolisthesis, Okudaira et al. demonstrated that CBT screws were associated with shorter duration of surgery (148 min vs. 184 min), less blood loss (132 ml vs. 184 ml), and similar pain and functional outcomes compared with traditional screws. Overall, CBT was less invasive, required less exposure and resulted in faster recovery with fewer complications (9).

In our study, Solid fusion was achieved in 90% of operated levels in CBT group and 85% of PS group; this rate was comparable to those reported in previous studies. Sakaura et al. reported solid bone fusion in 90.9% of operated levels after single and two-level fusions in both CBT group and PS group. They found non-union in 4 patients in CBT and 2 patients in PS group, but non required revision surgery (10). We observed 3 (15%) patients experienced hardware-related complications in PS group, Screw malposition in 2 patient (10%) and one (5%) patient experienced screw loosening, had a diagnosis of osteoporosis and underwent CBT with excellent outcome after 12 months. In CBT group, 2 (10%) patients experienced screw malposition. Lee et al. found 2 (5%) patients with screw malposition in PS group (8). Dural tears occurred in 2 patients in each group, but CSF leakage stopped after 2 weeks of conservative treatment. In the current literature, dural tears have been reported in 4% to 15.6% of patients (11).

Recent studies have reported other complications, including superior facet joint violations (1.25%–9.1%), symptomatic adjacent segment disease, deep vein thrombosis or pulmonary embolism (3.8%), hematomas (1.1%–2.4%), and infection (1.3%–2.1%) (12). In our series, we observed superficial wound infections in 2(10%) patients one (5%) in each group, they respond well to conservative treatment- with no need to additional surgery- and symptomatic adjacent segment disease in 2(10%) patients one (5%) in each group, both patients completely improved with conservative treatment.

Overall, the currently available clinical evidence provides promising preliminary data demonstrating that the efficacy and safety of CBT screws is at least comparable to that of traditional pedicle screws. However, these clinical studies are limited due to the data published to date are too few and short to allow for definitive conclusion and formal recommendations (13).

Conclusion

The cortical bone trajectory takes advantage of a cortically based track through the pedicle, which may result in improved fixation strength compared with a traditionally placed pedicle screw in certain indications. The technique was initially advised for osteoporotic patients. Complications with this new technology have been low, and outcome studies have demonstrated excellent fusion rates as well as maintenance of reduction in cases of spondylolisthesis. Further clinical studies with long-term follow-up and larger sample sizes, are required to investigate the long-term outcomes of CBT technique for stabilization in various lumbar spine pathologies.

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