Journal of Clinical Neuroscience 22 (2015) 972–975

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Early clinical results with cortically based pedicle screw trajectory for fusion of the degenerative lumbar spine

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ARTICLE INFO

Article history:
Received 18 January 2015
Accepted 24 January 2015

Keywords:
Cortical
Degenerative
Lumbar
Pedicle screw
Spine

ABSTRACT

This study reviews the outcomes and revision rates of degenerative lumbar fusion surgery using cortical trajectory pedicle screws in lieu of traditional pedicle screw instrumentation. Pedicle screw fixation can be a challenge in patients with low bone mineral density. Wide posterior approaches to the lumbar spine exposing lateral to the facet joints and onto transverse processes causes an additional degree of muscular damage and blood loss not present with a simple laminectomy. A cortical bone trajectory pedicle screw has been proposed as an alternative to prevent screw pullout and decrease the morbidity associated with the wide posterior approach to the spine. We present a series of eight consecutive patients using a cortical bone trajectory instead of traditional pedicle screw fixation for degenerative conditions of the lumbar spine. A retrospective review of our institutional registry data identified eight patients who had cortical screws placed with the assistance of O-arm Stealth navigation (Medtronic Sofamor Danek, Memphis, TN, USA) from 2010–2013. We analyzed the need for revision, the maintenance of reduction and the incidence of screw pullout or breakage. Our review demonstrated that two of eight patients were revised at an average of 12 months. The reasons for these revisions were pseudarthrosis and caudal adjacent segment failure. All patients who were revised had frank screw loosening. We present early clinical results of a new technique that has been shown to have a better fixation profile in laboratory testing. Our less than favorable early clinical results should be interpreted with caution and highlight important technical issues which should be considered.

1. Introduction

A significant effort has been made by surgeons and spinal instrument manufacturers over the past decade to decrease the morbidity associated with surgical exposure of the spine. Percutaneous access points and image guidance can reduce the periosteal dissection traditionally used for spinal fusion surgery. While there is a paucity of evidence demonstrating better outcomes using minimally invasive techniques, many surgeons anecdotally feel that the morbidity associated with minimally invasive surgery is less than with traditional wide surgical exposures [1–7].

Recently, a new technique has been described for inserting small diameter screws into the lumbar spine in an inferomedial to superolateral trajectory through the pars interarticularis [8–10]. These so-called "cortical screws" have the theoretical advantages of gaining fixation within cortical bone within the pars and base of the pedicle and requiring minimal muscle dissection as the starting entry point is much more medial than that of a traditional pedicle screw. In *in vitro* biomechanical testing, such screws have been shown to have a higher pullout strength compared to traditional pedicle screws, likely due to the strong bone-screw interface in cortical bone [8,11,12]. Given that the majority of bone mass is lost from cancellous bone with aging, there is some rationale for engaging screws within more cortical bone [13]. To our knowledge, clinical studies that describe the primary use of such screws in patients undergoing fusions of the lumbar spine with short to mid-term follow-up have not previously been published. The purpose of this study is to report on our early experience using this cortical screw technique in patients undergoing decompressions and fusions of the lumbar spine. We present our early experience using a cortically based pedicle trajectory for fusions of the degenerative lumbar spine.

2. Methods

All patients at our institution in whom such cortical screws were used for fixation in a lumbar decompression and fusion

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http://dx.doi.org/10.1016/j.jocn.2015.01.010
0967-5868/

procedure were retrospectively reviewed. Length of stay in hospital, the initial discharge standing radiographs, follow-up radiographs and additional operative notes were all reviewed. In the initial operative notes, any comments about screw purchase, need for screw redirection and overall satisfaction about appropriate trajectory was noted. If any post-operative CT scans were available evaluating screw trajectory these were also reviewed.

The technique itself employed O-Arm and Stealth navigation in all patients (Medtronic Sofamor Danek, Memphis, TN, USA). An initial O-arm scan is taken intra-operatively with a four sphere reference frame attached to the patient. A five sphered wand is then used to directly navigate the drill as it followed along the intended trajectory. Drill holes were tapped carefully for 5–10 mm each with the same diameter of the cortical screw (line to line). The screw was subsequently placed along the same trajectory.

Initial and follow-up radiographs or CT scans were evaluated for signs of hardware loosening or failure especially at the bone-screw interface. On follow-up radiographs 2 mm of anterolisthesis was categorized as a loss of previous reduction. The majority of patients did not have validated clinic outcome measures as part of their initial and subsequent follow-up evaluations. Notes were made in their clinical documentation, however, whether they were satisfied or unsatisfied with their clinical outcome. Additional information was sought in the patient chart about the need for ongoing pain medications, epidural steroid injections and pain specialist referrals.

3. Results

Eight patients with at least 1 year follow-up underwent cortical screw fixation between July 2011 and December 2013. The procedures were performed by one of four Fellowship-trained spine surgeons. The average length of follow-up for all patients was 16.4 months. The average age was 66.9 years (range: 40–87). The majority of patients were fused at L4–L5 with one patient having a fusion performed at L3–L4 and another from L3–L5. An interbody device was used in five of the eight patients. No post-operative infections occurred with this approach.

Of the eight patients reviewed, two were revised, four demonstrated loss of reduction during the course of their clinical follow-up, five demonstrated evidence of frank screw loosening. Overall, five out of eight patients described being satisfied with their clinical outcome at final follow-up. Full details of all patients are presented in Table 1.

Two of the eight patients (patient 4 and 5) were revised at 12 months from their initial operation. Both patients presented with back pain but only patient 5 had a pseudarthrosis. Patient 4 was revised for adjacent segment failure at the level below the fusion; this level appeared normal on initial post-operative radiographs but a spondylolisthesis was noted on radiographs 9 months later. It was significant to note, however, that all screws were loose at the time of revision in both patients. Cultures were sent to rule out infection but no organisms grew after five days. Patient 6 was offered revision surgery for ongoing back pain, loss of reduction and screw loosening but declined due to her advanced age and medical co-morbidities.

Screw loosening was also clear on radiographs in three additional patients (6, 7 and 8). Screws were loose on plain films with obvious haloing around the L5 screws. Fixation in L4 was also compromised in Patient 6 as confirmed with CT scans. Fixation in L4 as judged with plain films for Patients 7 and 8 did not demonstrate any obvious loosening.

There was a loss of reduction in four of eight patients (5, 6, 7, and 8). Three of these did not use an interbody device. As previously noted, all patients who had loss of reduction also had gross loosening of screws. The three patients without interbody support who lost initial reduction were well reduced on initial post-operative standing radiographs. All three patients demonstrated loss of reduction on follow-up radiographs at the 3 month post-operative clinical visit (Fig. 1).

Post-operative CT scans were available for three patients in total (1, 6 and 8). Patient 1 had a CT scan 18 months post-operatively due to ongoing back pain and poor clinical performance overall. This CT scan did not demonstrate any screw loosening and did show very good trajectory of the screws from medial to lateral in a caudal to cranial direction through the pedicles (Fig. 2). CT scan for Patient 6 demonstrated frank loosening of screws and loss of reduction. The CT scan for Patient 8 had clear hallowing around the L4 and L5 screws bilaterally (Fig. 3). None of the post-operative CT scans demonstrated breaching of the pedicle.

Overall, at final or most recent follow-up, all patients had documented an overall satisfaction with their procedure in the chart and this was subsequently noted by the treating surgeon. Three of eight patients were dissatisfied with their procedure overall and reported that it did not meet their pre-operative expectations. All three of these patients were seeing a pain specialist for symptoms that were similar to what they were experiencing pre-operatively.

4. Discussion

To our knowledge, this is the first report with more than 1 year follow-up of patients having a lumbar fusion with a cortically based screw trajectory as a primary procedure. There is one paper that we are aware of that reports the clinical outcomes of the use of a cortical trajectory screw but this is for revision spinal surgery and the treatment of asymptomatic adjacent segment changes [14]. The major findings of our series were the unexpected early screw loosening and the early loss of reduction with this new technique. There were two revisions by 1 year and one additional patient was offered a revision surgery.

Despite demonstrating excellent overall screw pullout strength and favorable mechanical characteristics in the laboratory, our early clinical data suggests that this new technique is not without

Table 1
Summary of eight lumbar spine fusion patients undergoing fixation with cortically based pedicle screw trajectory

Patient	Age (years)	Sex	Surgical spine levels fused	Maintenance of reduction	Revision	Screw loosening	Interbody device	Months followed	Satisfied
1	60	M	L4–L5	Y	N	N	Y	18	N
2	53	F	L4–L5	Y	N	N	Y	18	Y
3	40	M	L4–L5	Y	N	N	Y	18	Y
4	64	M	L3–L4	Y	Y	Y	Y	16	Y
5	82	F	L4–L5	N	Y	Y	Y	17	Y
6	87	F	L3–L5	N	N	Y	N	19	N
7	69	F	L4–L5	N	N	Y	N	12	Y
8	80	F	L4–L5	N	N	Y	N	12	N

F = female, M = male, N = no, Y = yes.