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Can Sacropelvic Fixation Improve Outcome of Long-Segment Lumbar Spine Fusion in Patients with Degenerative Lumbar Spine Disease?

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ABSTRACT

Background Data: Posterior spinal fusion has been more and more used for management of degenerative disorders of the lumbosacral spine. Long-segment fixation of three or more motion segments extending down to the sacrum has been associated with loosening or failure of S1 screws.

Purpose: Comparison between fixations extending to S1 and those to S2 (S2-alar-iliac screws) with sacropelvic fixation in the management of multilevel lumbar spinal canal stenosis.

Study Design: Prospective controlled cohort study.

Patients and Methods: We recruited 45 patients suffering from lumbar spinal canal stenosis of 3 or more levels including 16 revision cases in the whole group. In 23 patients, posterior lumbar fusion extended to S1 and in 22 fixations extended to S2. Pre- and postoperative clinical evaluation included Visual Analogue Scale (VAS) for back pain and Oswestry Disability Index (ODI). Preoperative radiological evaluation included plain X-ray and MRI. Postoperative clinical evaluation included VAS and ODI and radiological evaluation included X-ray and CT. The mean follow-up duration was 14.1±1.7 months (range, 12–24) in S1 group and 14.3±1.9 months (range, 12–24) in S2 group.

Results: The mean VAS improved from 8.1±0.8 to 4.9±0.9 in S1 group and from 7.7±1.2 to 1.95±0.79 in S2 group. The mean ODI improved from 77±10.5 and 76.8±10.9 to 45.9±7.3 and 29.5±8.4 in S1 and S2 groups, respectively. Two dural tears were repaired intraoperatively with no postoperative consequences. Seven cases in S1 group had loosening of S1 screw that was evident at 6-month follow-up.

Conclusion: Sacropelvic fixation in the form of S2-alar-iliac screws provides a significantly more rigid construct, decreasing the incidence of loosening of S1 screws and improving the overall outcome in patients treated with long lumbar fusion. (2019ESJ199)

Keywords: Sacropelvic fixation; Pedicle screw loosening; Long-segment fixation; Lumbar spine.

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INTRODUCTION

The number of spinal fusion operations has been increased possibly due to the increased life expectancy of the population and the prevalence of degenerative lumbar spine disorders that may include spinal canal stenosis, foraminal stenosis, degenerative scoliosis, and spondylolisthesis.[14] Posterior spinal fusion has been increasingly used for management of degenerative disorders of lumbosacral spine. Long-segment fixation of three or more motion segments extending down to the sacrum has been associated with loosening or failure of S1 screws.[5,9]

Many factors have been proposed for this type of complication. The sacrum is composed mainly of cancellous bone which is subject to excessive mechanical stresses considerably increasing with fusion of multiple motion segments above it. It also has large pedicle diameter with short pedicle length that allows usage of only short screws, so these screws will sustain more stresses making them more prone to loosening or failure. Decreased bone mineral density is associated with high incidence of sacral screws loosening, so it is important to examine it preoperatively when long-segment fusion is planned.[2,9]

It has also been proposed that sacral screws angulation in the axial plane is an important factor for its pullout strength which increases with more angulation of screws rather than being parallel to each other. Sagittal imbalance of lumbosacral spine with high difference between lumbar lordosis and pelvic incidence is also associated with excessive loads over the sacral screws leading to failure.[11]

This study was performed to assess whether addition of sacropelvic fixation to long-segment lumbosacral fixation can decrease the incidence of S1 pedicle screw loosening in treatment of multilevel degenerative lumbar spinal canal stenosis or not.

PATIENTS AND METHODS

Forty-five patients with multilevel degenerative lumbar spinal canal stenosis were managed surgically with laminectomy and instrumented posterior fusion between May 2015 and September 2018 in the Spine Unit, Orthopedic Department, Zagazig University Hospital. Patients were randomly enrolled into one of two groups. In S1 group, the fixation was extended to S1 which was augmented by L5-S1 TLIF (transforaminal lumbar interbody fusion) and S1 bicortical screws (Figure 1), while, in S2 group, the fixation was extended to S2-iliac screws (Figure 2). Quasi-randomized protocol was used to allocate the patients in either procedure based on patients' numbering: patients with odd numbers were enrolled in S1 group and those with even numbers in S2 group. Patients enrolled into the study had degenerative lumbar spinal canal stenosis whether fresh or revision cases with at least 3 levels affected and L5-S1 level is included. We excluded patients presenting with spinal canal stenosis in association with infection, tumors, morbid obesity, and severe osteoporosis with DEXA score more than -3.5.

S1 group included 23 patients (10 males and 13 females) and S2 group included 22 patients (9 males and 13 females). The mean age was 53±4.2 (range, 45–60) in S1 group and 55.6±3.9 (range, 47–63) in S2 group. The mean body mass index (BMI) was 26.2±3 (range, 22–31) in S1 group and 26.4±1.8 (range, 24–30) in S2 group. The mean bone mineral density (BMD) was -1.4±0.4 (range, -2.8–0) in S1 group and -1.5±0.5 (range, -2.9–0) in S2 group. Six patients in S1 group (26.1%) and 6 in S2 group (27.3%) were smokers (Table 1). We had 8 revision cases in each group.

Visual Analogue Scale (VAS) for back pain was assessed preoperatively and at every follow-up, with 0 indicating no pain and 10 maximum pain. Functional outcome was measured using the Oswestry Disability Index (ODI). The mean preoperative VAS for back pain was 8.1±0.8 in S1 group and 7.7±1.2 in S2 group. The mean

preoperative ODI was 77±10.5 in S1 group and 76.8±10.9 in S2 group (Table 1).

Radiologically, all patients underwent Magnetic Resonance Imaging (MRI) of lumbosacral spine. Plain lumbosacral spine X-ray anteroposterior, lateral, and dynamic views were obtained to measure lumbar lordosis (LL), pelvic tilt (PT), and pelvic incidence (PI). Measurement of bone mineral density (BMD) with DEXA scan was conducted to all patients with obvious decreased bone density in preoperative X-ray; teriparatide injection was administered for 6 months preoperatively to patients with T-score less than -2.5 (2 patients in each group).

Postoperative patients were submitted for plain X-ray through follow-up visits where preoperative parameters were revaluated, in addition to fusion evaluation where S1 pedicle screw loosening appears in plain X-ray as a halo sign showing a radiolucent line of more than 1 mm around the screw.

Computed Tomography (CT) of lumbosacral spine was done to all patients in the immediate postoperative period to assess intraosseous length (IOL) and axial angle of S1 screw (Figure 3).[11]

Postoperative care was similar in both groups; the suction drain was removed when discharge was less than 100 ml in 12 hours. All patients were advised to walk on the 2nd postoperative day and were discharged from hospital 4 days postoperatively. The patients were followed up at 2, 4, and 6 weeks and 3, 6, and 12 months postoperatively, then every year.

All statistics were performed using SPSS 23.0 for Windows (SPSS Inc., Chicago, IL, USA). Measurements of angles in X-ray and CT-scan were done using Surgimap™ application.

RESULTS

The total number of operated levels was 155 levels in 45 patients. In S1 group, 14 patients had 3-level fusion extending from L3 to S1 and 9 patients 4-level fusion extending from L2 to S1. In S2 group, 11 patients had 3-level fusion extending from L3 to S2 alar screw and 11 patients 4-level fusion extending from L2 to S2 alar screw. All patients have the clinical diagnosis of multilevel degenerative lumbar spinal canal stenosis with significant low back pain and claudicating sciatica. Features of clinical instability as catching and mechanical low back pain were reported in 27 patients (14 in S1 group and 13 in S2 group) and 16 revision cases distributed equally in both groups.

Mean follow-up period was 14.1±1.7 months (range, 12–24) in group 1 and 14.3±1.9 months (range, 12–24) in group 2. The mean preoperative LL was 29.5±5.6 in S1 group and 28.3±5.9 in S2 group. The mean preoperative PT was 35.2±1.7 in S1 group and 34.9±1.2 in S2 group (Table 2). The operated levels in S1 group were 3 in 12 patients and 4 in 11 patients, while the operated levels in S2 group were 3 in 8 patients and 4 in 14 patients. The mean operative time was 112.3±14.3 min (range, 90–133) in S1 group and 131.7±14.3 (range, 110–156) in S2 group, and the difference in operative time between the 2 groups was statistically significant. The mean blood loss was 537.9±184.8 ml (range, 260–900) in S1 group and 625.2±166.6 (range, 350–925) in S2 group, and this difference was not statistically significant (Table 3).

The mean postoperative final VAS was 4.9±0.9 in S1 group and 1.95±0.79 in S2 group. The mean postoperative final ODI was 45.9±7.3 in S1 group and 29.5±8.4 in S2 group. The mean postoperative final LL was 48.55±3.1 in S1 group and 48.5±3.2 in S2 group. The mean postoperative final PT was 17.2±1.5 in S1 group and 17.8±1.1 in S2 group. There was no statistical difference between LL, PI, and PT in S1 and S2 groups (Tables 2–5).

S1 screw diameter was 7 mm in 6 patients and 6 mm in 17 patients in S1 group, while S1 screw diameter was 7 mm in 7 patients and 6 mm in 15 patients in S2 group. We usually use 6 mm screws but 7 mm screws were used in osteoporotic patients and in some revision cases with intraoperative loose screws. The mean IOL measured in postoperative

CT-scan of S1 screw was 34.3±1.9 mm (range, 31.5-39) in S1 group and 33.8±1.8 mm (range, 31.5–38) in S2 group. The mean S1 screw axial angle was 11.70±2.6 (range, 8–16) in S1 group and 12.20±2.5 (range, 8–17) in S2 group. There was no statistical difference between screw diameter, axial alignment, and IOL in S1 and S2 groups (Table 1). S1 screw loosening occurred in 7/23 (30%) patients in S1 group and did not occur in S2 group and this was statistically significant (P< 0.001). We noticed that VAS and ODI showed improvement in all patients at 1st follow-up at 3 months. However, in patients with screw loosening of S1, there was no further improvement at subsequent follow-ups. In S1 group, seven patients showed no fusion at L5-S1 segment. Two of them had no fusion at L4-5 segment as well.

Table 1. Demographic and clinical characteristics of the patients.

Parameters	S1 group (N=23)		S2 group (N=22)	*t*-test	P value
Age (years)	53.3±4.2 (45–60)		55.6±3.9 (47–63)	1.932	0.06
BMI	26.2±3 (22–31)		26.4±1.8 (24–30)	0.307	0.76
BMD	-1.4±0.4 (-2.8–0)		-1.5±0.5 (-2.9–0)	0.577	0.667
PI	57.2±3.5 (52–65)		56.5±2.9 (51–63)	0.754	0.4550
S1 D	6.2±0.4 (6-7)		6.3±0.5 (6-7)	0.665	0.51
S1 Axial	11.7±2.6 (8–16)		12.2±2.5 (8–17)	0.607	0.547
S1 IOL	34.3±1.9 (31.5–39)		33.8±1.8 (31.8–38.1)	0.949	0.348
OP Time	112.3±14.3 (90–133)		131.7±14.3 (110–156)	4.499	<0.001**
Blood loss	537.9±184.8 (260–900)		625.2±166.6 (350–925)	1.645	0.107
FUP	14.1±1.7 (12–18)		14.3±1.9 (12–18)	0.21	0.834
	Number (%)		Number (%)	X^2 test	P value
Sex	Male	10 (43.5%)	9 (40.9%)	0.03	0.861
	Female	13 (56.5%)	13 (59.1%)		
Smoking	No	17 (73.9%)	16 (72.7)	0.008	0.928
	Yes	6 (26.1%)	6 (27.3%)		
Levels	3	12 (52.2%)	8 (36.4%)	1.138	0.286
	4	11 (47.8%)	14 (63.6)		

BMI: body mass index; BMD: bone mineral density; PI: pelvic incidence; S1D: S1 screw diameter; S1 Axial: S1 screw axial angle; S1 IOL: S1 screw intraosseous length; OP Time: operative time; FUP: follow-up.

Table 2. Comparison between preoperative results of both groups in terms of different parameters.

Parameters	S1 Group (N=23)	S2 Group (N=22)	*t*-test	P value
LL	29.5±5.6	28.3±5.9	0.684	0.498
PT	35.2±1.7	34.9±1.2	0.719	0.476
VAS	8.1±0.8	7.7±1.2	1.451	0.154
ODI	77±10.5	76.8±10.9	0.07	0.944

LL: lumbar lordosis; PT: pelvic tilt; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index.

Table 3. Comparison between pre- and postoperative results of S1 group (N=23) in terms of different parameters.

Parameters	Preoperative	Postoperative	Improvement %	Paired *t*-test	P value
LL	29.5±5.6	48.55±3.1	64.6	16.749	<0.001**
PT	35.2±1.7	17.2±1.5	13.2	6.095	<0.001**
VAS	8.1±0.8	4.9±0.9	39.5	14.077	<0.001**
ODI	77±10.5	45.9±7.3	40.4	16.492	<0.001**

LL: lumbar lordosis; PT: pelvic tilt; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index.

Table 4. Comparison between pre- and postoperative results of S2 group (N=22) in terms of different parameters.

Parameters	Preoperative	Postoperative	Improvement %	Paired *t*-test	P value
LL	28.3±5.9	48.5±3.2	71.4	15.62	<0.001**
PT	34.9±1.2	17.8±1.1	19.5	11.143	<0.001**
VAS	7.7±1.2	1.95±0.7	74.7	19.376	<0.001**
ODI	76.8±10.9	29.5±8.4	61.6	18.44	<0.001**

LL: lumbar lordosis; PT: pelvic tilt; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index.

Table 5. Comparison between postoperative results of both groups in terms of different parameters.

Parameters	S1 group (N=23)	S2 group (N=22)	*t*-test	P value
LL	48.55±3.1	48.5±3.2	0.048	0.962
PT	17.2±1.5	17.8±1.1	1.575	0.123
VAS	4.9±0.9	1.95±0.7	11.093	<0.001**
ODI	45.9±7.3	29.5±8.4	6.862	<0.001**
FUP	14.18±3.4	14.18±3.9	0.0	1.0

LL: lumbar lordosis; PT: pelvic tilt; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; FUP: follow-up.

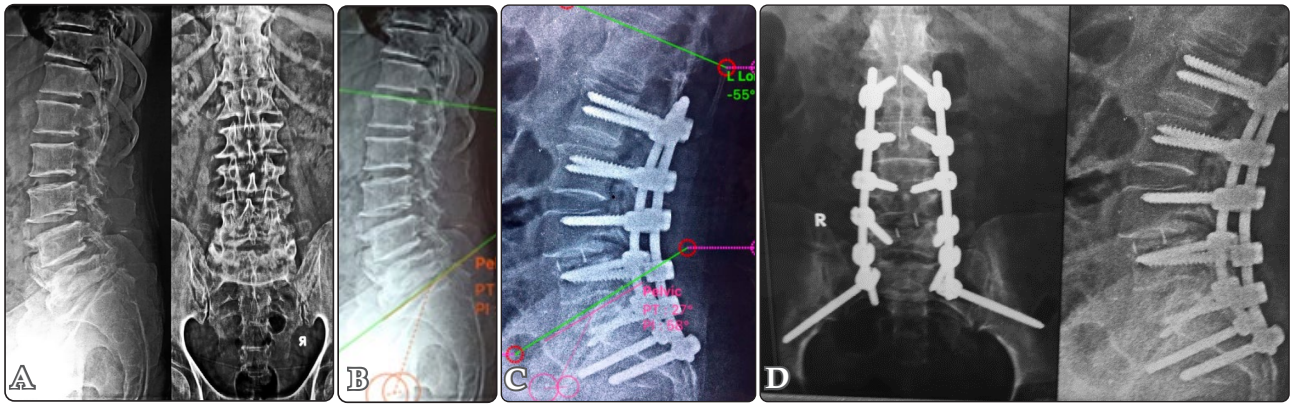

Figure 1. (A) Preoperative AP and lateral X-ray. (B) Preoperative lateral X-ray with measurement of LL: -44; PI: 55; PT: 19. (C): Postoperative lateral X-ray showing measurement LL: -55; PI: 55; PT: 27. (D) Final follow-up X-ray showing preservation of parameters and stable construct.

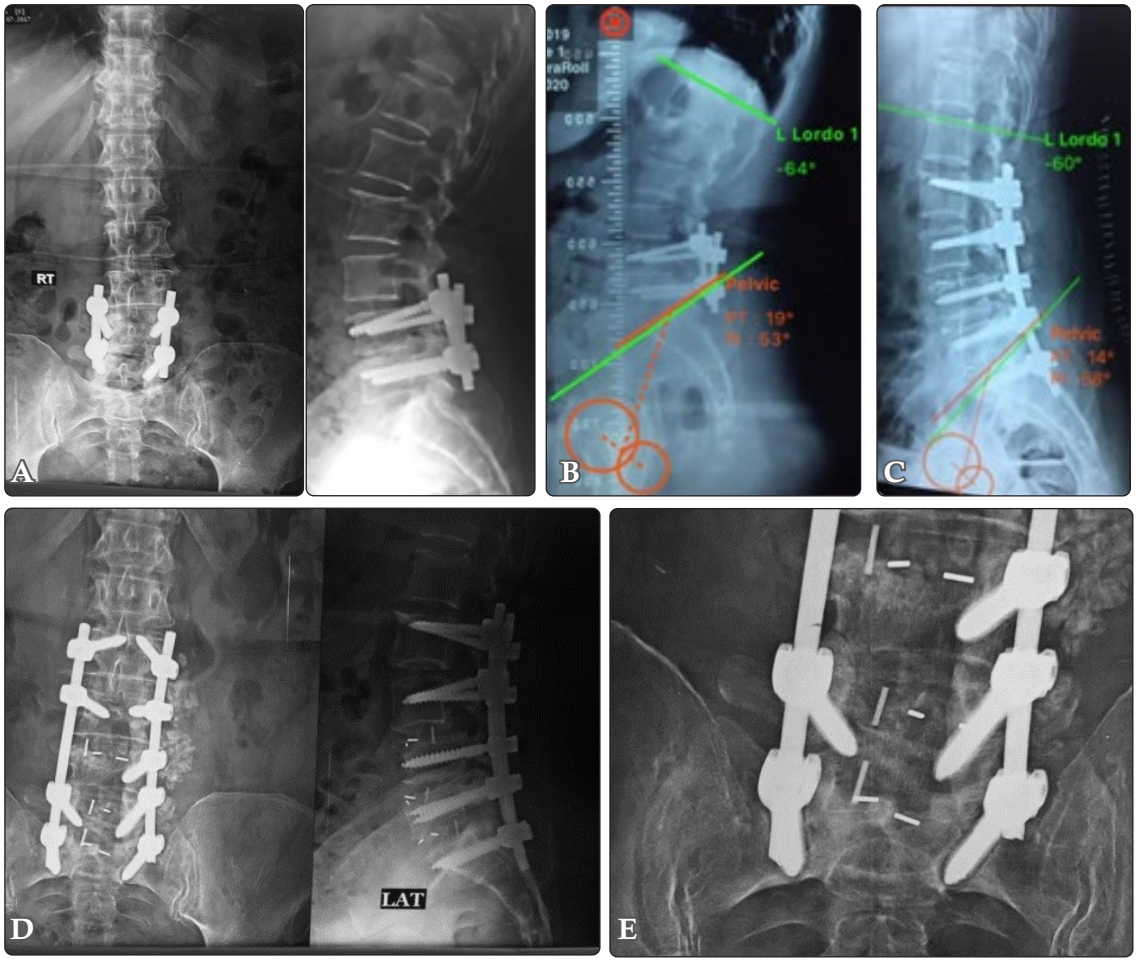

Figure 2. (A) Preoperative AP and lateral X-ray. (B) Preoperative lateral X-ray with measurement of LL: -64; PI: 53; PT: 19. (C) Postoperative lateral X-ray showing measurement LL: -60; PI: 53; PT: 14. (D) and (E) Final follow-up X-ray showing S1 loosening of the screw.

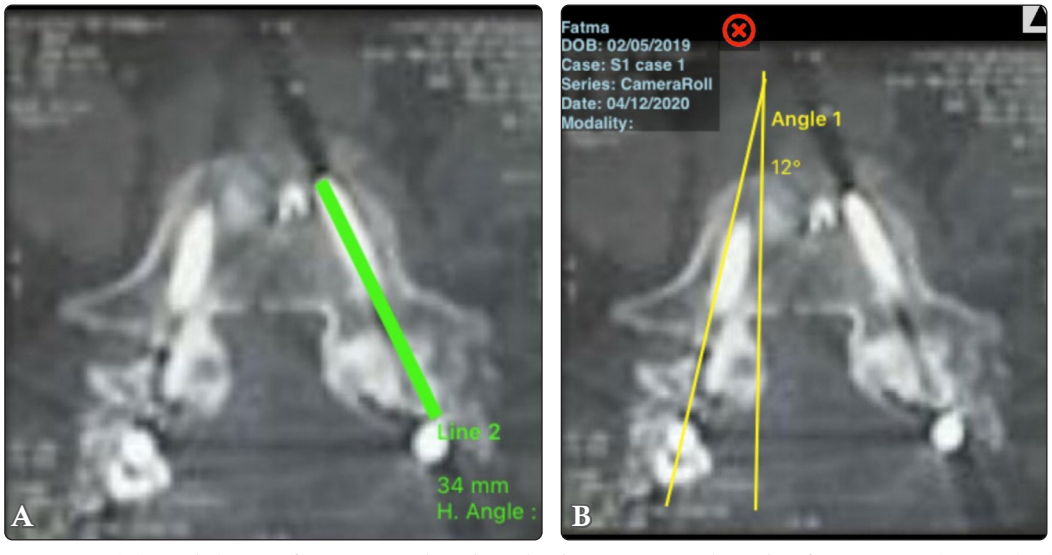

Figure 3. (A) Axial cut of CT-scan showing the intraosseous length of S1 screw (34 mm). (B) Axial angle of S1 screw.

DISCUSSION

This study was done to assess if addition of sacropelvic fixation would decrease incidence of S1 screws loosening in patients undergoing long-segment lumbosacral fusions for degenerative lumbar canal stenosis and decrease the incidence of pseudoarthrosis in L5-S1 segment. The application of S2-iliac screw in group 2 had shown significant maintenance of S1 screw stability with significant improvement in the functional outcome in comparison to that of the other group.

Long-segment fixation of three or more motion segments extending down to the sacrum has been associated with loosening or failure of S1 screws.[5,9] Many techniques have been used to improve stability of lumbosacral fixation including interbody fusion of L5-S1 segment, for example, TLIF, XLIF, or ALIF, increasing pullout strength by cement augmentation or using bicortical screws.[1,4,6,10]

Extending fusion to the ileum using sacropelvic fixation in the form of S2-iliac screws has been found to considerably increase the rigidity of construct.[8,12] Biomechanical studies comparing S2-iliac and iliac screws have been made by Shin et al.[15] and Burns et al.[3], and both studies have found that these two methods were associated with less implant failure; moreover, Burns et al.[3] found that using S2-iliac screws was associated with less morbidity than iliac screws.

S1 and S2 groups were comparable with no significant difference regarding demographic data (age and sex) or smoking habit. There were also no considerable differences regarding preoperative BMI, BMD, VAS for back pain, and ODI. Both groups had comparable preoperative spinopelvic parameters as lumbar lordosis LL and pelvic incidence PI.

Both groups showed significant improvement in the overall VAS and ODI postoperatively when compared to the preoperative values ($P<0.001$). At the first follow-up (at 3 months), all patients showed improvement of VAS and ODI (due to improvement gained from adequate decompression and the fixation of the diseased levels). However, in seven patients of group 1 who had S1 screw loosening, there was no further improvement at subsequent follow-ups. Four of them showed decreased improvement of VAS and ODI at final follow-up.

In a retrospective cohort study on 250 patients, Bukov et al.[2] found that decreased bone quality is the most frequently reported contributing factor to screw loosening. In our study, we measured BMD for all patients who had plain radiological signs of osteoporosis and 6-month teriparatide therapy was administered to those patients with proved osteoporosis prior to surgery.

A study by Nishimura et al.[13] found a strong positive correlation between clinical outcome and preoperative lumbar lordosis. Decreased lordosis with more difference from the pelvic incidence resulted in high complication rate. They recommended that long lumbar fusions should be long enough to achieve adequate lumbar lordosis proportional to pelvic incidence. They also emphasized that sacropelvic fixation in the form of S2-alar-iliac screws provided mechanically robust construct in challenging and revision cases.

Lumbar lordosis was significantly improved in both groups ($P<0.001$); however, the correction in both groups was comparable with no significant difference in between 2 groups.

Loosening of S1 screw occurred in 30% of patients of S1 group and this was interestingly clear in their postoperative VAS and ODI when compared to S2 group. This indicates better rigidity of construct when fusion extends to the pelvis in long-segment fusion. These results were similar to those obtained by Harris and Kebaish[9] in which loosening of S1 screws occurred in 27 patients (24.4%) of total patients treated with fusion down to S1. The mean duration of loosening in this study was 7.3±4.1 months.

Many studies have reported frequent nonunion in the lumbosacral segment compared to other levels.[1,4,6,7,10] Finger et al.[7] found that L5-S1 pseudarthrosis occurred in 19% in cases of

multilevel fusion extending to only S1 and found that 0% had pseudarthrosis when fixation was extended to the iliem. Keller et al.[10] found S1 screw insufficiency in 12/50 patients (24%). S2 group showed better improvement in their clinical parameters when compared to S1 group because of better rigidity which coincides with results obtained by Finger et al.[7]

We think our study would be better if we could include more patients and increase duration of follow-up. It is also better to have multicentered results that can be arranged in a future study. This study recommends addition of sacropelvic fixation to all patients undergoing long lumbar fusion for degenerative spinal canal stenosis as this improves outcome and decreases sacral screws loosening.

CONCLUSION

Sacropelvic fixation in the form of S2-alar-iliac screws provides a significantly more rigid construct, decreasing the incidence of loosening of S1 screws and improving the overall outcome in patients treated with long lumbar fusion.

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الملخص العربي

هل امتداد التثبيت للحوض يحسن نتائج الجراحة في حالات التثبيت الطويل للفقرات القطنية والعجزية؟

البيانات الخلفية: يستعمل التثبيت الخلفي للفقرات القطنية والعجزية بكثرة في حالات انحلال الفقرات. وعندما يتم التثبيت لعدة فقرات (أربعة فأكثر) ممتدا إلى الفقرات العجزية تزداد إمكانية حدوث تخلخل في المسامير المثبتة للفقرة العجزية الأولى.

الغرض: دراسة مقارنة بين تثبيت الفقرات القطنية الممتد إلى الفقرة العجزية الأولى وتثبيت الفقرات الممتد إلى الفقرة العجزية الثانية مع تثبيت الحوض في حالات ضيق القناة العصبية القطنية متعددة المستوى.

تصميم الدراسة: هذا البحث هو دراسة استطلاعية أجريت على ٤٥ مريض. المجموعة الأولى تشمل 23 مريضا وتم التثبيت لأسفل حتي الفقرة العجزية الأولى. المجموعة الثانية امتد التثبيت حتي الفقرة العجزية الثانية مع تثبيت الحوض.

المرضى والطرق: تم تقسيم المرضى عشوائيا إلى مجموعتين. وقد تضمن فحص المرضى إكلينيكيا عدة قياسات لمقارنة شدة الألم ونشاط المرضى اليومي قبل وبعد إجراء العملية (مؤشر أوزويستري). كما تم عمل أشعة عادية وأشعة رنين مغناطيسي للمرضي قبل إجراء العملية. وكذلك تم عمل الأشعة السينية والمقطعية وذلك لتقييم انصهار الفقرات بعد إجراء العملية. متوسط متابعة المرضي بعد العملية 14.1+1.7 شهرا في المجموعة الأولى و14.3+1.9 شهرا في المجموعة الثانية.

النتائج: تحسن معدل الإحساس بالألم من 8.1+0.8 إلى 4.9+0.9 في المجموعة الأولى ومن 7.7+1.2 إلى 1.95+0.79 في المجموعة الثانية. كما تحسن مؤشر أوزويستري من 77+10.5 إلى 45.9+7.3 في المجموعة الأولى ومن 76.8+10.9 إلى 29.5 + 8.4 في المجموعة الثانية. حدث قطع بالأم الجافية في حالتين تم علاجهما بلا مضاعفات. كما حدث تخلخل بالمسامير المثبتة للفقرة العجزية الأولى في سبع حالات بالمجموعة الأولى.

الاستنتاج: امتداد التثبيت إلى الفقرة العجزية الثانية مع تثبيت الحوض يزيد من قوة تثبيت الفقرات ويقلل معدل حدوث تخلخل بالمسامير المثبتة للفقرة العجزية الأولى ويحسن من النتائج النهائية لعمليات التثبيت الطويل للفقرات القطنية والعجزية.