Original Article

Adult idiopathic *de novo* lumbar scoliosis: Analysis of surgical treatment in 14 patients by "only fixation"

ABSTRACT

Objective: The authors report their experience with 14 cases having adult idiopathic *de novo* lumbar scoliosis (AIDLS) and presenting with the predominant symptoms of claudication pain in the low back and legs. The patients were treated by only multisegmental stabilization, and the surgical procedure aimed for arthrodesis without any form of bone or soft‑tissue decompression. The clinical outcome of this novel form of surgical treatment is presented.

Materials and Methods: During the period of June 2014 to June 2019, 14 patients having AIDLS (degenerative scoliosis) were surgically treated. Apart from clinical and radiological guides, instability was diagnosed on the basis of direct physical observation of the status of articulation and by manual manipulation of bones of the region. The Camille transarticular facet screw fixation technique provided a quick, safe, and strong segmental spinal fixation. An additional inter‑screw metal link plate provided intersegmental stability at selected levels. The Oswestry Disability index and visual analog scale were used to assess the patients before and after surgery and at follow‑up. In addition, a personalized Patient Satisfaction Score was used to assess the outcome of surgery.

Results: Clinical symptomatic recovery was observed in all patients in the immediate postoperative period. During the average follow‑up period, 100% patients had varying degrees of symptomatic relief.

Conclusions: Spinal instability is the nodal point of pathogenesis of spinal degeneration‑related AIDLS. Only fixation of the involved spinal segments is necessary, and decompression by bone or soft‑tissue resection is not necessary.

Keywords: Lumbar canal stenosis, lumbar scoliosis, spinal degeneration, transarticular screw fixation

INTRODUCTION

The clinical entity of adult idiopathic *de novo* lumbar scoliosis (AIDLS) has been under intense clinical discussion.[1-7] As the name suggests, adults having no history of lumbar spinal deformity develop a progressively increasing lumbar scoliosis without having any predisposing related cause. "Old" age‑related disc degeneration has been primarily implicated as the basis of pathogenesis. The general understanding is that the deformity eventually results in neural compression‑related symptoms that are more pronounced on the concave side of the spinal curve. Clinical symptoms usually begin with the observation of deformity and progress to mimic those of lumbar canal stenosis. Decompression of the neural structures has historically formed the basis of surgical treatment.[4] While patients with lumbar canal stenosis are generally considered to have a stable spine, several authors have more recently identified

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spinal instability as the probable cause or an important association in cases with AIDLS.[1,4-7] While the gold standard treatment of lumbar canal stenosis is multisegmental wide decompressive laminectomy, the current world opinion seems to favor the need for short- or long-segment spinal stabilization in addition to decompression surgery in cases with AIDLS.[1,4-7]

In the year 2010, it was suggested that rather than the disc degeneration or reduction of disc space, it is muscle weakness related to their disuse, abuse, or injury that is the nodal point of initiation and propulsion of cascade of secondary spinal alterations that are included in the general definition of the term "spinal degeneration."[8,9] Majority of muscle bulk of the spine is located on its posterior and posterolateral surface and caters to life-long standing human position. The muscles have their fulcrum over the facet joints. Muscle weakness-related "telescoping" of the facets wherein the inferior facet of the rostral vertebra "vertically" dislocates over the superior facet of the caudal vertebra forms the point of genesis of spinal degeneration.[10] Spinal instability was identified to be the primary pathology. Gratifying clinical results were achieved following surgical treatment that involved only spinal stabilization without any form of "decompression" for both cervical and lumbar spinal degeneration that leads to symptoms of radiculopathy and/or myelopathy.[11-17] In the long run, we identified regression of all secondary manifestations that are attributed to be pathological in spinal degeneration.[11-17] It was observed that AIDLS is a manifestation of multisegmental lumbar spinal instability that is more pronounced at a single level and on one side. In this report, our experience of treating 14 cases with AIDLS by "only-fixation" without any form of decompression is presented. Our literature search has not identified reports of such a form of treatment.

MATERIALS AND METHODS

During the period of June 2014 to June 2019, 14 patients were identified to have AIDLS. The patients were treated in the neurosurgical departments of the authors. These patients have been analyzed retrospectively. Minimum follow-up following the surgical treatment is of 6 months. All patients provided written informed consent, and all clinical tests and surgical procedures were conducted according to the principles of the Declaration of Helsinki. Patients analyzed in the previous reports specifying the treatment strategy for patients having lumbar canal stenosis have been included in the study.[15]

The minimum parameters that characterized patients into AIDLS included the following:

1. Age above 50 years
2. No preexisting lumbar spinal deformity during childhood or young age
3. No history of injury to the spine. No history of any spinal infection. No other known predisposing etiological factor
4. Presence of lumbar spinal deformity prior to the development of "major" symptoms
5. Minimum Cobb angle of 10°.

The presenting symptoms are elaborated in Table 1. All patients presented with the major symptom of "claudication pain" that was considered diagnostic of the presence of lumbar canal stenosis. Apart from lumbar spinal deformity and complain of backache that radiated to one (8 patients) or both (six patients) legs, other major symptoms included tingling paraesthesiae (11 patients), numbness (11 patients), and weakness of one (three patients) or both legs (two patients). None of the patients in the series had significant urinary or bowel symptom. At the time of admission for surgery, the symptoms were so severe that six patients preferred wheelchair assistance. The exact duration of symptom of spinal deformity could not be pointed. The duration of pain as a symptom ranged from 9 to 56 months (average 15 months). Clinical parameters that were monitored both before and after surgery included the visual analog scale, the Oswestry Disability Index (ODI), and a specially designed Patient Satisfaction Score (PSS).

All patients underwent dynamic flexion-extension plain radiography of the entire spine and computed tomography (CT) scan and magnetic resonance imaging (MRI) of the lumbosacral spine. Dynamic flexion-extension CT scan of the lumbosacral spine was done in all patients. Three-dimensional imaging of the lumbosacral spine was done in 12 patients. MRI screening of the entire spine was done in nine patients.

Radiological observations are elaborated in Table 2. The parameters assessed included lumbar lordosis, lumbar scoliosis, and the sacral slope both before and after surgery. Lumbar lordosis was measured by using Cobb's method on a lateral radiograph. Lumbar scoliosis was measured by

Table 1: Presenting complaints

Presenting complaints	Number of patients
Back pain	14
Leg pain	
Unilateral	8
Bilateral	6
Intermittent claudication	14
Tingling paresthesias	11
Numbness	11
Weakness in one or more muscle groups	5

measuring the Cobb's angle of the scoliotic segment on an anteroposterior radiograph. The sacral slope was measured using the angle between the plane of the sacrum and the horizontal plane.

Surgical treatment

All patients underwent "only fixation" as treatment, and the surgery was aimed at arthrodesis of the treated spinal segments [Figure 1]. No decompression by resection of bones, soft tissues, ligaments, osteophytes, or disc was done. No attempt was made to manipulate the bones or the instruments to reduce the spinal scoliosis. The patients were placed in standard prone surgical position that maintained the spine in flexed position and obliterated the lumbar lordosis. The levels of spinal segments that were fixated were determined on the basis of the presenting clinical symptoms and radiological guides that included levels of dural tube compression related to osteophytes, bulging/herniated disc, or ligamentous compression. Apart from spinal levels suggested by clinical and radiological guidance, adjacent lumbar spinal levels were assessed during surgery for evidences of spinal instability. Direct physical observation of spinal instability by manual manipulation of bones of the region, presence of unusual/abnormal mobility at the facetal articulation, presence of osteophytes in the vicinity of facets, and direct evidence of facetal listhesis were major indicators of unstable spinal segments that were considered for stabilization. Multi-level segmental spinal fixation was done by transarticular technique as described by Roy-Camille and Saillant in 1972.[18] The joint cavity was opened and articular cartilage was removed widely by using screwing motion of an osteotome. Monoaxial titanium screws measuring 18–20 mm in length and 2.6 mm in width were used. At all levels, at least two-screw (double insurance) fixation was done.[19] In five levels, three screws were inserted in a transarticular fashion. The number of spinal levels that were stabilized is shown in Table 3. At the primary level of spinal deformity, at the level of spondylolisthesis or at the level where fracture of pars inter-articularis was seen or suspected on radiographs, a two- or three-hole plate fixation was done that connected or linked the two fixated segments as shown in Figure 1. Such

Table 2: Radiological measurements

Radiological parameter	Preoperative: Range (mean)	Postoperative: Postoperative (mean)
Lumbar lordosis (°)	30-51 (39)	35-64 (56)
Lumbar scoliosis (°)	20-28 (23)	9-14 (11)
Sacral slope (°)	30-45 (37)	45-62 (55)

Figure 1: Images of a 56-year-old female patient: (a) T2-weighted magnetic resonance imaging shows multisegmental lumbar dural tube compression by varying sizes of osteophytes. (b) Computed tomography scan shows varying sizes of anterior and posterior osteophytes. (c) Anteroposterior view of computed tomography scan showing lumbar scoliosis. Large lateral osteophytes are seen on the concave side of the scoliosis curve. (d) Three-dimensional computed tomography scan of the lumbosacral spine showing the spinal deformity. (e) Anteroposterior view of the plain radiograph. (f) Postoperative computed tomography scan of the lumbar spine. (g) Computed tomography scan cut showing transarticular facet fixation. A cross-link plate and screw fixation can be seen. (h) Postoperative radiograph showing the reduction in the scoliosis. Metal implants can be seen

intersegmental inter-screw metal links or fixation was done at one level in six patients. No bone (lamina, facet, or pedicle), soft tissue (ligamentum flavum, intervertebral disc), or osteophyte removal was done to affect decompression of the dural tube or the traversing neural structures. Following screw implantation, all interspinous processes and interlaminar ligaments were widely resected. Spinous processes were cut sharply at the base after sectioning all the attached muscles. The bone obtained following sectioning of the spinous process was shredded into small pieces and used as graft material. The laminae, pedicle, and bone adjoining the transarticular screws were decorticated to make the host environment suitable for graft. The patients were instructed to avoid excessive back movements, particularly those that involved flexion and extension of the back for a period of 6–8 weeks. External orthosis in the form of a lumbar belt was advocated for the period. After this period, the patients were allowed to progressively resume their normal lifestyle after confirmation of the status of implants. Imaging was done in the immediate postoperative phase and at follow-up examination.

Outcome assessment

Postoperative neurological and radiological assessments were done in the immediate postoperative period, after about 3 months and at the last follow-up. Apart from the authors, two independent qualified neurosurgeon assessors who were specially deployed for the purpose did all clinical and radiological assessments. The clinical assessments were done on the basis of inpatient clinical data, video recordings, telephonic conversations, and direct neurological examination [Tables 4 and 5]. To objectively assess the clinical status, based on a brief questionnaire in the patient's own vernacular language, a personalized patient satisfaction scoring (PSS) system was developed [Table 6].[15]

RESULTS

In all patients, relief from the major presenting symptom of backache and radiating pain was "significantly" or completely appreciated in the "immediate" postoperative period. During the period of follow-up that ranged from 6 to 68 months (average 32 months), all patients continued to have clinical and symptomatic recovery. Out of six patients who were brought on wheelchair for treatment to the hospital, all walked independently and without any "significant" symptom on follow-up. The extent of clinical recovery is shown in Tables 4-6. On monitoring by personalized PSS, 87% were "highly satisfied" with the outcome [Table 6].

Deformity outcome

Although no direct attempt was made to correct the spinal curvature, none of the patients complained of the symptom of spinal deformity during the follow-up assessment. Radiological assessments at the last follow-up are shown in Table 2. It was obvious that the monitoring parameters suggested that there was reduction in the extent of spinal deformity. In all our patients, there was an improvement in lumbar scoliosis from 20 to 28° (mean 23°) preoperatively to 9°–14° (mean 11°) postoperatively following surgery and at follow-up. The lumbar lordosis improved from 30° to 51° preoperatively (mean 39°) to 35°–64° (mean 56°) postoperatively. The sacral slope changed from 30° to 45° (mean 37°) preoperatively to 45°–62° (mean 55°) postoperatively.

No patient needed any reoperation for persistent or recurrent symptoms. There were no infections and implant-related complications. Arthrodesis of the treated spinal segments was considered successful when at the minimum follow-up of 6 months the clinical improvement was satisfactory, screw position remained stationary, evidences of bone fusion were seen across the facets, and dynamic imaging did not show

Table 3: Radiological features

Feature	Number of patients
Radiological level involved	
L1-2	3
L2-3	6
L3-4	14
L4-5	14
L5-S1	12
Apex of scoliosis	
L3-4	9
L4-5	5
Number of levels fixed	
L1-2	8
L2-3	10
L3-4	14
L4-5	14
L5-S1	14

Table 4: Pre- and post-operative visual analog scale scores

VAS	Preoperative	Immediate postoperative	At 6-month follow-up
Back pain	6-9 (8.6)	1-3 (2.3)	0-1 (0.2)

VAS - Visual analog scale

Table 5: Pre- and post-operative Oswestry Disability Index scores

ODI (%)	Preoperative	At 6-month follow-up
0-20 minimal disability	-	12
21-40 moderate disability	2	2
41-60 severe disability	6	-
61-80 crippled	5	-
81-100 bedridden	1	-

ODI - Oswestry Disability Index

Table 6: Patient Satisfaction Score

Parameter	Score 0: Not satisfied	Score 1: Minimally satisfied	Score 2: Satisfied	Score 3: Remarkably satisfied
Are you happy with the operation?	-	-	2	12
Are you relieved of back and leg pain?	-	-	-	14
Can you walk better?	-	-	-	14
Would you recommend the operation to someone else?	-	-	-	14

relative movements of any vertebral component. With these basic and minimal parameters, successful arthrodesis was achieved in all patients.

DISCUSSION

AIDLS is a relatively frequent clinical observation. Our literature search suggests that 6%–68% of total "old-age" adult human population has AIDLS.[1-7] The growing age of humans across the globe has increased the disease burden. Age-related disorders and associated comorbidities such as diabetes and hypertension and generalized or focal osteoporosis have major therapeutic and surgical implications.

The pathogenesis of the entire process has been incriminated to be age-related disc degeneration. It is unclear if AIDLS is a discrete clinical entity or is an advanced stage or version of spinal degeneration. Clinical and radiological features mimic those of lumbar canal stenosis. Multisegmental osteophyte, bulging disc, and buckling of ligamentum flavum-related dural tube compression are uniformly identified. At the primary site of lumbar scoliosis, eccentric disc degeneration and disc space reduction, facetal arthrosis, and pars interarticularis fracture are some of the more commonly identified pathological features. All the patients in the presented series had classical symptoms that could be related to the advanced form of lumbar canal stenosis. Unlike in acute disc prolapse where the pain symptom is on the side of the dome of the scoliotic spinal curve, the symptoms in AIDLS are predominantly on the concave side of the spinal curve. Stenosis of the bony spinal and neural canal on the concave side of the curve is presumed to be the possible reason. Essentially, the symptoms mimicked those classically described in cases with lumbar canal stenosis, being more predominant on one side. Symptom wise, the entity is difficult to differentiate from lumbar canal stenosis. This was probably the reason that nine cases in the series were included in our earlier report that was focused on the surgical treatment of lumbar canal stenosis.

On general assessment of the existing literature, it is clear that the patients in the presented group had relatively severe symptoms that were of longer duration when compared to other similar series described in the literature. At the time of presentation, six patients were bedridden and preferred wheelchair mobilization. This may be related to the relatively poor patient population treated by the authors in their charitable public hospital that caters free treatment. Low education level, inadequate early diagnosis, excessive relying on alternative medical treatment, and long travel distances are possibly some factors that delayed medical assistance.

Decompression of the neural structures has been the basis of surgical treatment of AIDLS. Decompression includes small- or long-segment wide laminectomy and resection of ligamentum flavum. While some authors prefer facet-sparing laminectomy to preserve spinal stability, others have suggested the need for foraminotomy, facetectomy, and osteophyte/disc resection to enhance the decompression.[1-7] Some authors have advised to extend the decompression more laterally on the concave side of the scoliotic curve. Despite the universal recommendation of decompression, current literature seems to favor the additional need for stabilization of the spine. This is because some authors identify instability to have a major role in the pathogenesis of the deformity and others observe that decompressive surgery that involves bone removal may make the spine more susceptible to the development of instability and worsening of scoliosis.[1-7] Accordingly, some authors identify the role of short-segment spinal fixation, while others identify the advantages of long-segment spinal stabilization.[5-7] Despite the fact that short- or long-segment stabilization is currently the more recommended surgical procedure in addition to decompression, the difficulties and dangers of performing fixation surgery in these "old-" age patients having various comorbidities in addition to osteoporotic bone architecture that makes screws difficult to adequately anchor have been recognized. Difficulty in performing pedicular screw implantation due to altered spinal angulation has been identified. Possibilities of blood loss and anesthesia-related complications have been reported in the literature. The incidence of complications following short- and long-segment fusion reported in most series has been high, ranging from 20% to 80%.[2,5]

We earlier identified muscle weakness-related spinal instability as the core issue in the genesis of spinal degeneration in general and lumbar canal stenosis in particular.[8,9] Telescoping of the spinal segments and facetal listhesis related to vertical spinal instability was identified to be the primary point of pathogenesis.[10] Buckling of the ligamentum flavum, osteophyte formation, and bulging/herniation of the disc led to reduction in the spinal and/or neural canal dimensions. Spinal deformity as in AIDLS seems to be an extension of the process of spinal degeneration. Muscle weakness-related spinal instability was observed to be the basis of pathogenesis of both AIDLS and spinal degeneration. Identification of instability that is manifested at the facets that are laterally located away from the neural structures is difficult or impossible. On the other hand, consequences of instability that lead to a number of bone, ligament, disc, and osteophyte related manifestations are relatively easily identified. Although instability has been speculated to be the cause of AIDLS, it is difficult or impossible to demonstrate instability on dynamic imaging. Although the possibility of instability following spinal decompression has been widely recognized, confirmatory radiological parameters have not been identified.

In the year 2010, we identified the role of muscle weakness in the generation of spinal instability and subsequent progression toward spinal degeneration.[8,9] As our understanding of issues related to spinal degeneration matured, we realized that neural compression or deformation was not the cause of symptoms in chronic or longstanding and progressive clinical condition of spinal degeneration. Subtle instability-related "micro-injuries" appeared to be the point of genesis of symptoms. It was observed that only spinal fixation is a valid and rational form of surgical treatment for cervical and lumbar spinal degeneration-related radiculopathy and myelopathy.[11-17] We recently published our experience with treating cervical and lumbar canal stenosis with only fixation and demonstrated the futility of decompression as treatment.[15,20] We have been so much convinced about the role of only stabilization as treatment that our recent editorials have suggested that spinal decompression can become historical operation and that the term multi-level spinal "stenosis" is a misnomer and should be changed to multi-level spinal instability.[21,22]

The key issue in the surgical treatment was to identify the levels of spinal instability. It was observed that degeneration-related spinal instability is usually not limited to a single spinal segment but generally involves multiple segments. In cases with AIDLS, the instability is not localized to a single segment but is multisegmental. In addition to the clinical and radiological guides, intraoperative observation of stability of the spinal segments in levels adjacent to those suggested by radiological examination by physical observation and manual manipulation of the bones was identified to be crucial. Observation of osteophytes in the vicinity of the facets, weak articular capsule or open articulation, and direct observation of telescoping of the facets determined the unstable spinal segments.

Transfacetal screw insertion technique as described by Roy-Camille and Saillant in 1972 was identified to be relatively simple and biomechanically strong.[18] The technique provided the possibility of "zero-movement" situation and an environment most conducive for bone fusion that seems to be superior when compared to all the other available techniques. The screws traversed the thickest and strongest part of the vertebra and their course through the articulation blocked all movements. Inserting two or three screws at each articulation can provide "double" or "triple" insurance stabilization.[19] The technique of fixation could be performed remarkably quickly, and there was no need for navigation or even fluoroscopy to monitor the site and trajectory of screw insertion. The status of facetal health and stability could be observed directly by visual and manual inspection prior to fixation. In addition, the status and strength of stabilization after screw insertion could be directly assessed. The technique of fixation of two spinal segments by interposing a metal plate adds versatility to the procedure. Such intersegmental addition of plate for stabilization is particularly useful in cases with AIDLS and where spondylolisthesis related to pars fracture is associated.

Although no direct attempt was made to reduce the scoliosis, postoperative radiological monitoring parameters showed varying degree of recovery from scoliotic deformity. There was a remarkable recovery in the lumbar scoliosis as measured by the Cobb's angle following surgery. The Cobbs angle reduced from 20° to 28° (mean 23°) in the preoperative period to 9°–14° (mean – 11°) in the postoperative period. Reduction of scoliosis during positioning for surgery that involved spinal flexion and muscle relaxation during anesthesia is the possible reason of spine straightening prior to its surgical fixation. None of the patients complained of any spinal deformity on follow-up assessment.

Our remarkable clinical outcome obtained in the present series and in our previous reports related to surgical treatment of lumbar and spinal degeneration wherein only spinal fixation without any form of decompression was done clearly demonstrates the efficacy of our surgical strategy. The symptomatic recovery was observed in the immediate postoperative period that was remarkable and lasting. The clinical results suggest that surgical procedures that involve direct or indirect "decompression" of neural structures are unnecessary and avoidable, and probably have a negative impact on the overall clinical outcome.

CONCLUSIONS

The clinical complex of AIDLS is an outcome of muscle weakness-related spinal instability. Spinal stabilization is the treatment.

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Conflicts of interest

There are no conflicts of interest.

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