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Evaluating the Efficacy of S2 Alar Iliac Screws in a Single - Stage Posterior Approach Surgery for Treatment of Lumbosacral Spondylodiscitis: A Retrospective Clinical Study

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Abstract: ***Background: Spondylodiscitis is an infectious condition affecting the vertebral body, intervertebral disc, and surrounding paravertebral tissues. Reconstruction of the lumbosacral segment is technically demanding due to its biomechanical conditions and anatomical characteristics. This clinical outcome study aims to provide significant insights into the efficacy and advantages of using S2AI screws in a single - stage posterior approach to address persistent instability, recurrent infection, and facilitate fusion in severe spondylodiscitis. Methods: Six patients diagnosed with infective lumbo sacral spondylodiscitis and underwent surgical debridement and fixation between August 2022 and March 2024 were enrolled in this study. Patient demographic, pre surgery and post - surgery Visual Analog Score (VAS), Oswestry Disability Index (ODI), and post operative complications were analysed. Results: The six patients were monitored for an average of 14 months. VAS declined in all six patients. The average preoperative VAS was 8.17 and dropped significantly to an average of 2.6 following surgery. ODI showed a continuous increase in scores over the course of the follow - up period. The average ODI score prior to surgery was 81, and it decreased substantially to an average score of 32 after surgery. Conclusion: Utilizing the S2AI fixation method for lumbosacral spondylodiscitis is a reliable and safe treatment option that can yield promising outcome in restoring lumbosacral stability.***

Keywords: S2AI, Spondylodiscitis, Lumbosacral reconstruction, Long segment, Posterior approach

1. Background

Spondylodiscitis is an infectious condition affecting the vertebral body, intervertebral disc, and surrounding paravertebral tissues. The causes of this condition can primarily be categorized as pyogenic, tuberculosis - induced and postoperative. Its incidence ranges between 1 in 20, 000 and 1 in 100, 000 people annually and the prevalence seems to be increasing. Spondylodiscitis can pose significant severity and potential life - threatening risks with 2% - 20% mortality of hospitalized patients, in large part because of delayed diagnosis [1]

The lumbosacral segment, situated at the junction between the spine and pelvis, presents unique anatomical and biomechanical features. These characteristics make the reconstruction of the lumbosacral segment in cases of instability and deformity a technically challenging procedure. [2]

Lumbosacral spondylodiscitis can lead to severe kyphotic deformity, instability, and neurological impairment, for which surgical intervention is recommended. [3] Debridement and stability restoration are effective by an anterior approach, which provides direct access to the affected area. Nonetheless, there is reported intra operative complications of retrograde ejaculation and iliac artery damage with this approach [4]. Comprehensive debridement, high rates of bone fusion, and efficient deformity correction are provided by combined anterior and posterior approaches. They do, however, come with a higher risk of surgical trauma and morbidity [5]. On the other hand, the posterior technique, which has become popular recently, simultaneously offers stronger three - column fixation by pedicle screws and circumferential decompression [6].

The sacrum is the cornerstone of the pelvic ring. One of the challenges in treating patients with lumbosacral spondylodiscitis, who have damage to the L5 and S1 vertebrae, is choosing the right internal fixation technique for a posterior - only surgery. This is crucial for providing stable fixation and ensuring a successful return to function after surgery [7]. For lumbopelvic fixation, iliac screw (IS) fixation is considered to be an efficient technique. However, the IS approach has several disadvantages, such as the requirement for offset connector utilization, potential problems with prominent screws causing soft tissue symptoms, and substantial soft tissue dissection [8].

The S2 - alar - iliac (S2AI) screw approach was created to provide better mechanical qualities, less tissue dissection, a smaller profile, and easier assembly in order to solve these drawbacks [9]. However, literature discussing the clinical efficacy of S2AI techniques specifically for treating lumbosacral spondylodiscitis remains limited.

It has been reported that short - segment fixation, debridement, and fusion via the posterior approach is a reliable treatment option for single - level spondylodiscitis with satisfactory functional recovery [10]. However, the degree of infection - induced anterior column degradation raises doubts about the stability of a short segment construct.

The goal of our review is to provide significant insights into the efficacy, safety, and potential advantages of utilizing S2 alar iliac screws within a single - stage posterior approach to

address persistent instability, recurrent infection, and facilitate fusion in cases of severe bony compromise caused by infection. Through the evaluation of clinical outcomes and complications, we aim to refine surgical methodologies and treatment strategies in the management of complex spinal conditions involving infection and significant bony instability.

2. Methods

We conducted a retrospective review of our data archive to analyze cases of lumbosacral spondylodiscitis treated with surgical debridement and long - segment fixation using S2AI screws from August 2022 to March 2024. The surgeries were all conducted by the same senior surgeon.

The criteria for inclusion in this study were: (1) Infection involving the L4/5 or L5/S1 disc space (2) patients who underwent debridement, bone grafting, and lumbopelvic fixation with S2AI screw. and (3) a minimum follow - up period of 9 months. Excluded from the study were patients with pre - existing sacral destruction, spinal neoplasms, or other medical disorders preventing them from undergoing internal fixation

Surgical procedure
Under general anaesthesia, open pedicle screw fixation was carried out. Screws were not inserted to the pedicle if the vertebral body was clinically diseased. We fixed at least two levels above till iliac as intended when the destruction of the vertebral body was severe.

S1 and S2 posterior foramen were identified. The entry point was positioned 1 mm lateral and inferior to the S1 posterior foramen. A starter awl is used to mark pedicle entry point. The screw trajectory direction was 20°–30° caudally in the sagittal plane and around 40° lateral in the transverse plane, aim at the anterior inferior iliac spine (AIIS), This point is roughly two finger - widths above the superior border of the greater trochanter of the femur [11]. A sharp pedicle probe was advanced around three to four centimetres toward the sacroiliac joint at the specified trajectory until resistance was felt, this indicated that the sacroiliac joint had been reached. A tip ball probe was then used to ensure that the surrounding bony walls and floor had no cortical breached. Next, the pedicle probe was carefully hammered to penetrate the double - layer cortex and continue into the upper ischial notch. The ball tip probe was once more used to confirm the soundness of the walls within the screw channel. After intraoperative fluoroscopy confirmation, a polyaxial pedicle screw in a diameter of 7.0–8.5 mm and a length of 75–90 mm was inserted. Lastly, the connecting rods between the S2AI screws and the proximal screws were assembled and secured with nuts [12].

As all patients had leg pain and neural compression symptoms, a laminectomy and transforaminal debridement were done at the identified index level. The space created after meticulous intervertebral disc debridement was filled with autogenous bone graft from heathy nibbled spinous processes and lamina. For posterior fusion, autologous spinous bone as well as tiny bone pieces gathered after decompression were also utilized.

Postoperative management
Patients were mobilised 48 to 72 hours post - surgery and wore lumbosacral orthosis to assist ambulation. After 3 months, the orthosis was removed. A post - operative CT scan and X - ray were acquired to evaluate fusion in the months that followed. Four individuals received intravenous antibiotics to treat pyogenic infections A typical 12 - to 18 - month therapy regimen consisting of isoniazid, rifampicin, ethambutol, and pyrazinamide was used to treat two individuals with tuberculous (TB) spondylitis.

Outcome Measures
The Visual Analog Scale (VAS) was used to evaluate pain. Using the ODI questionnaire, we evaluated how our surgical technique impacted the patient's daily activities. Every patient underwent evaluations prior to surgery as well as during the last follow - up visit. The degree of bone fusion at the index region was evaluated using CT scans at minimum 6 months, and all post operative complications were noted.

Statistical Analysis
IBM SPSS Version 22.0 was used to analyze all of the data. Values are presented as means ± standard deviation in figures and text, unless otherwise noted. The student's t - test (two - tailed) was used to compare preoperative and postoperative measurement data, such as VAS and ODI scores. P value less than 0.05 was deemed statistically significance.

3. Results

Patient population
All six patients had comprehensive radiological and clinical data and were monitored for a minimum of nine months. The average follow - up period was 14.57 months, and the average patient age was 54 years. After evaluating the clinical presentation, radiological features, microbiological cultivation, and tuberculin reactivity, the patients were diagnosed with either pyogenic spondylitis or tuberculosis. All six patients had infections that were unresponsive to conservative treatment. Each patient underwent preoperative magnetic resonance imaging (MRI) and X - rays. Baseline data of all the patient are shown in **Table 1**.

Table 1: Demographics and baseline data of study patients

Case	Age (yr)	Sex	Comorbids	Symptoms	Diagnosis
1	50	Male	None	Back pain & radicular pain	Pyogenic Spondylodiscitis L5/S1
2	33	Female	None	Back pain & radicular pain	TB Spondylitis L4/L5 with L5 destruction
3	51	Male	Hypertension	Back pain & radicular pain	TB Spondylitis L3/L4/L5 with L5 destruction
4	63	Male	Diabetes	Back pain & radicular pain	Pyogenic Spondylodiscitis L5/S1
5	63	Male	Hypertension	Back pain & radicular pain	Pyogenic Spondylodiscitis l4/l5/S1
6	64	Male	Diabetes	Back pain & radicular pain	Pyogenic Spondylodiscitis L4/L5/S1

Clinical Outcomes

During the follow - up period, the pain levels (measured by VAS) decreased in all six patients. The average VAS score before surgery was 8.17. It significantly dropped ($P < 0.001$) to an average of 2.6 after the surgery (see Table 2). Using the ODI questionnaire to assess the impact of surgery on the patients' daily lives, the results indicated a consistent improvement in scores over the follow - up period. The average ODI score before surgery was 81, and it decreased significantly ($P < 0.05$) to an average score of 32 after surgery (**Table 2**).

Table 2: Clinical infectiveness data

Case		VAS			ODI (%)		Fusion Time
	Pre op	Post Op 3days	Post op 9months	Pre - Op	Post Op 3days	Post Op 9months	
1	8	3	2	88	38	16	8 months
2	8	3	2	78	30	14	7 months
3	9	2	1	84	32	12	6 months
4	7	3	2	81	33	13	7 months
5	8	1	1	79	37	14	No fusion
6	9	3	3	80	24	10	8 months
Mean	8.17	2.5	1.83	81	32	13.3	
P value	<0.05			<0.05			

Complications

Within two weeks after the procedure, one patient in our study developed a postoperative surgical site infection. The same patient had no fusion seen in one year of follow - up.

Imaging evaluation of the fusion

Fusion was observed in all our patients except for one. The average time for fusion to occur after surgery was 6.8 months, and one patient developed pseudoarthrosis. (Table 2).

Figure 1 and **Figure 2** depict two typical cases

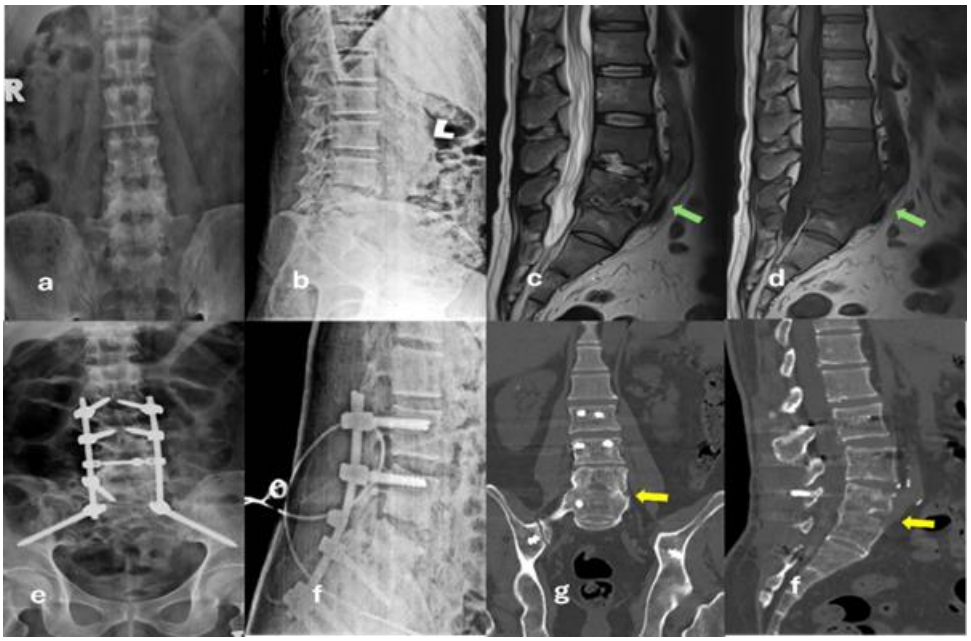

Figure 1: 53 year old male diagnosed with Tuberculous Spondylodiscitis who underwent debridement and posterior stabilisation till s2AI (a-d) Pre surgery x ray and MRI scans shows spondylodiscitis L3-L5 with bony involvement. (e,f) Anteroposterior and lateral Xray at day 3 post op show a well placed L2 to s2AI fixation. (g,h) Fusion seen in CT images done 12 months post op.

Figure 2: 63- year old male diagnosed with pyogenic spondylodiscitis who underwent debridement and posterior stabilisation till s2AI (a-d) Pre surgery x ray and MRI scans shows spondylodiscitis L5/S1. (e,f) Anteroposterior and lateral Xray 3 days post surgery shows a well placed L2 to s2AI fixation. (g,h) Fusion seen in CT images done 10 months post op.

4. Discussion

Infective spondylodiscitis is a contagious ailment characterized by the destruction of the disc and vertebrae, leading to intense lower back pain, neurological issues, and changes in lumbosacral biomechanics [1]. The severe infection often restricts patients' daily activities, diminishing their quality of life [13]. Lower back pain stands out as the most prevalent clinical symptom in patients with spinal infections, often accompanied by nonspecific symptoms [13]. Surgery becomes necessary when there is ongoing destruction despite adequate antibiotic therapy and when neurological impairment or spinal instability are present [14].

The main objectives of surgical intervention focus on managing the infection by eliminating the source of sepsis and restoring spinal stability. Various surgical methods have been described and proven effective in treating lumbosacral spondylodiscitis. In our research, severe lumbosacral infections with vertebral body loss were addressed through a one - stage approach involving long segment posterior pedicle screw fixation and intervertebral disc bone grafting with autogenous bone graft post debridement.

Follow - up assessments revealed satisfactory outcomes in terms of deformity correction and fusion for all except one patient. The primary focus of our study lay in identifying suitable fixation instruments for lumbosacral infections. Spine surgeons have increasingly utilized the posterior - only approach in recent years due to its benefits, including able to provide comprehensive decompression of neural structures and accomplishing three - column stabilization through pedicle screw instrumentation [14, 15].

S1 pedicle screws lack the necessary biomechanical strength for patients with L5 or S1 destruction and radical debridement can further compromise the integrity and stability of the pelvic ring. As the lowest instrumented vertebra in lumbosacral infections, it is extremely improbable that S1 can provide a secure fixation. Consequently, a lumbopelvic fixation is often required [8].

The two main methods of lumbopelvic fixation that are frequently used are S2 alar iliac (S2AI) and iliac (IS) screws. The use of IS fixation can meet the biomechanical requirements of lumbopelvic fixation. However, due to the high notch of the screws, it requires additional incisions and more extensive soft tissue dissection [16]. Moreover the low cortical density along the IS screw path is insufficient to ensure adequate anchorage force for long posterior instrumentation. This can lead to screw loosening and an increased risk of developing lumbosacral pseudoarthrosis. [8].

Illio sacral screw fixation is limited by issues such as symptomatic screw prominence, the requirement for additional off - set connecting rods, and extensive soft tissue dissection. Consequently, an alternate sacropelvic fixation technique with S2AI screws was developed with the intention of reducing these drawbacks [10]. Several recent studies have shown that the S2AI technique is superior to the IS screws in terms of implant stresses, symptomatic screw prominence, revision rates, and tissue dissection [17, 18].

Mazur et al. reported lesser reoperation rate for S2AI screws compared ISs. This difference may be attributed to higher rates of surgical site infection (SSI), wound dehiscence, and symptomatic screw prominence observed in the IS group. Therefore, individuals who are at risk of infection or wound problems may benefit from the S2AI approach [19]. Based on O'Brien et al., S2AI screws provide a stronger anchorage than IS screws when passing through the sacrum and sacroiliac joint [20]. Elder et al., has also reported that S2AI screws have greater pullout strength compared to IS screws [21].

A more crucial factor in favour of using S2AI is demonstrated in Ishida et al., who discovered that the S2AI technique was a more viable surgical option for elderly patients than the IS technique [22]. Hasan et al. 's meta - analysis further offered more clinical evidence that the S2AI method lowers the incidence of complications [23].

Fixation one level above and below the infected index region, has reported being able to stabilize and correct kyphotic angles in spondylodiscitis [11]. However spondylodiscitis, with its severity of infection, usually reduces the anterior column support. Keeping this in mind, we advocate stabilizing two vertebral bodies above and below the lesion to produce stronger posterior fixation and a better kyphotic angle correction, especially in patients with an osteoporotic spine. Posterior decompression through laminectomy can compromise spinal stability further and by employing a long segment fixation may provide sufficient strength to address this problem. This stabilization via long instrumentation accompanied by an interbody fusion is beneficial to streamline nursing care, facilitate early patient mobilization, and consequently mitigate the risk of complications associated with prolonged bed rest. Moreover, a sturdy fixation can promptly alleviate back pain [24].

Based on our research, each patient showed significant improvement in their clinical condition and received satisfactory treatment for their spinal infection. The effectiveness of the long - segment posterior lumbosacral fixation with S2AI screws was confirmed by the superior findings postoperative VAS and ODI scores compared to preoperative measurements. Throughout the follow - up period, pain and functional scores considerably improved from pre - surgery values.

After one year, fusion was successfully achieved in all cases except one, with no reported instances of implant failure or loosening during follow - up. The patient with pseudoarthrosis was complicated with recurrent infection and has been planned for anterior reconstruction. Our S2AI screws were easily attached to L5 and S1 pedicle screws without the need for connecting rods. Soft tissue disruption and resection were minimized, leading to significantly reduced surgery time and blood loss. This study is limited by its retrospective, single - center design, small sample size, and short follow - up duration. Furthermore, the study did not evaluate several key radiographic parameters, including sagittal vertical alignment and pelvic incidence. Future prospective, multi - center studies with larger cohorts and longer follow - up periods, incorporating comprehensive radiographic analysis, should be conducted to validate these findings

5. Conclusion

Our current study demonstrates that the S2AI fixation strategy is a reliable and secure approach for treating lumbosacral spondylodiscitis. Outcomes at our centre suggest this surgical technique yields satisfactory results in managing and reconstructing the lumbosacral region complicated by infection, instability, and deformity. However, the study's limitations indicate that further research with long - term follow - up and larger sample sizes is necessary to compare the outcomes of S2AI with other fixation methods.

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