



12-1-2022

Study of Sacroiliac fixation in patients with sacroiliitis associated with L5 Lythesis

Ahmed Gabal

Al-AZHAR Cairo university, dr.gabal921@gmail.com

Hany Zahy

Neurosurgery department Al-Azhar university, zahyhany@gmail.com

Ibrahim Ewis

Professor and Head of Neurosurgery Dep., Al-Azhar University, i_euis@yahoo.com

Follow this and additional works at: <https://aimj.researchcommons.org/journal>



Part of the [Medical Sciences Commons](#), [Obstetrics and Gynecology Commons](#), and the [Surgery Commons](#)

How to Cite This Article

Gabal, Ahmed; Zahy, Hany; and Ewis, Ibrahim (2022) "Study of Sacroiliac fixation in patients with sacroiliitis associated with L5 Lythesis," *Al-Azhar International Medical Journal*: Vol. 3: Iss. 12, Article 32. DOI: <https://doi.org/10.21608/aimj.2023.151002.2049>

This Original Article is brought to you for free and open access by Al-Azhar International Medical Journal. It has been accepted for inclusion in Al-Azhar International Medical Journal by an authorized editor of Al-Azhar International Medical Journal. For more information, please contact dryasserhelmy@gmail.com.

Study of sacroiliac fixation in patients with sacroiliitis associated with L5 lythesis

Ahmed Al-saeed Mohamed Ismaiel Gabal ¹M.B.B.Ch ; Ibrahim Gamiel Ewees ¹MD and Hany Ibrahim Mohamed yousef ¹MD .

*Corresponding Author:

Ahmed Al-saeed Mohamed Ismaiel Gabal
dr.gabal921@gmail.com

Received for publication July 17, 2022; Accepted December 31, 2022; Published online December 31, 2022.

doi: 10.21608/aimj.2023.151002.2049

Citation: Ahmed A. Ibrahim G. and Hany I. . Study of sacroiliac fixation in patients with sacroiliitis associated with L5 lythesis. AIMJ. 2022; Vol.3-Issue12 : 200-204.

¹Neurosurgery Department, Faculty of Medicine, Al-Azhar University, Cairo , Egypt.

ABSTRACT

Background: Chronic low back discomfort is frequently brought on by the sacroiliac joint. The SIJ may be involved in 15–30% of patients who attend for examination of low back pain.

Aim of the work: This study evaluates sacroiliac fixation in patients with sacroiliitis associated with L5 lythesis.

Patients and methods: In this prospective and retrospective study, 10 individuals with spinal disorders were examined. Ten patients with mechanical sacroiliac joint discomfort underwent sacroiliac joint fixation.

Results: Overall, this series' results showed that 7 patients (or 70%) had fully resolved their problems, 2 patients (or 20%), partially improved, and 1 patient (or 10%), had not.

Conclusion: Sacroiliac fixation was safe and efficient in the treatment of patients with sacroiliitis associated with L5 lythesis. Currently, one of the most widely used methods for spinopelvic fusion is S2AI screw fixation. Significantly fewer clinical and radiographic problems are linked to the S2AI method .

We need further comparison research with larger sample sizes and longer follow-ups to corroborate our findings and pinpoint the risk factors for unfavourable outcomes.

Keywords: Arthrodesis; Distraction; Interference; Recesses; Sacroiliac joint.

Disclosure: The author has no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the author.

Authorship: The author has a substantial contribution to the article.

Copyright The Author published by Al-Azhar University, Faculty of Medicine, Cairo, Egypt. Users have the right to read, download, copy, distribute, print, search, or link to the full texts of articles under the following conditions: Creative Commons Attribution-Share Alike 4.0 International Public License (CC BY-SA 4.0).

INTRODUCTION

Growing evidence points to the sacroiliac joint (SIJ) as a frequent source of persistent low back discomfort. The SIJ may be involved in 15–30% of patients who attend for examination of low back pain. ¹

Exercise, SIJ steroid injections, RF ablation of the sacral nerve roots' lateral branches, and open or minimally invasive SIJ procedures surgery are currently available treatments for SIJ dysfunction. ²

*Nonsurgical treatments are used to address the majority of cases of discomfort caused by the sacroiliac joint. Surgery is a possibility for patients with significant, strict pain linked to Lumbar vertebrae lythesis that interferes with their daily lives and is refractory to nonsurgical treatments. Sacroiliac joint fixation is the procedure. ³

The sacrum, which supports the spine, distributes pressure from the spine to the pelvis through the sacroiliac joints. Reconstructing the spine-pelvic connection as a result of surgical fixation enables early weight-bearing. ⁴

This work aimed to evaluate sacroiliac fixation in patients with sacroiliitis associated with L5 lythesis

PATIENTS AND METHODS

This is prospective and retrospective study that was conducted on 10 patients with spinal pathologies.

The following methods were applied for the studied cases:

Preoperative evaluation:

Clinical, radiographic, and other preoperative laboratory evaluations are performed on each patient to determine whether they are fit for general anesthesia. all patients were neurologically free. Parenteral analgesics are used for severe pain and oral analgesics for mild pain. The physician went over the surgical process and subsequent care with the patient and his relative, and he answered any questions the patient had regarding the procedure.

Clinical evaluation:

Personal history including: Name, Age, Sex, Occupation, Address and Special habits. History of back pain. Neurological disorders including: Sensory, Motor and sphincteric disorders. History of chest, cardiac or general health problems that may hinder anesthesia.

Examination: General examination including: Evaluation of hemodynamic state of the patient (Pulse, blood pressure, temperature and respiratory rate).

Spine examination: Inspection of the back and other related regions. Palpation of the spine. Evaluation of deformity especially in old cases. Neurological evaluation: A-Sensory examination: Superficial sensation including: Pain, Touch, Temperature, Perianal sensation. Deep sensation: Joint sensation:

Sense of joint motion, sense of position and deep pressure sense.

B-Motor examination for Muscle power. Reflexes: Superficial: Abdominal reflexes Planter reflex Deep: Knee reflex. Ankle reflex.

Radiological evaluation: plain X- ray, CT and MRI. After hospital admission to the following were done.

Preoperative preparation and positioning:

All of the patients were given prophylactic antibiotic (3rd generation Cephalosporin) 1gm before induction of anesthesia. The patients were positioned prone, under general anesthesia on a radiolucent table with a small towel under chest of the patient with hyper extension of the leg.

Operative techniques:

General anesthesia

The patient is kept in the prone position (back in semiflexion) on a typical spine table that is well-padded at pressure points. Along with the C-arm image intensifier, all the equipment is maintained available.

Midline lumbar incision of the skin and subcutaneous tissue

Subperiosteal separation of paravertebral muscles

Identification the lamina laterally up to the facet joint and transverse processes

Good leveling using C-arm

S2-alar-iliac screw technique

During the SAI fixation procedure, S2 alar iliac screws (S2AI fixation) are inserted from the S2 region of the sacrum, over the sacroiliac joint, and into the ilium. The S2 alar iliac (S2AI) screw must be placed distal to the S1 superior endplate, 5 mm inferior-lateral to the S1 foramen, and 25 mm inferior-lateral to the midline. Since the S2AI screws are typically aligned with the S1 pedicle screws at the more medial entrance joint site, it is simple to attach the lumbosacral rod to the distal anchor without the use of medial to lateral connectors or several separate fascial incisions.

Aiming directly above the anterior inferior iliac spine, the screw should ideally be inclined 40 degrees laterally in the transverse plane and 40 degrees caudally in the sagittal plane (AIIS). The S2AI screw's pullout strength has increased since it traverses three distinct cortical bone structures in the sacroiliac joint. An S2AI screw typically measures 80 to 100 mm in length. The S2AI screw's pullout strength is increased if it is positioned just above the greater sciatic notch, close to the thick cortical bone. Due to improved visualisation of the screw crossing the SI joint, the AP view is commonly employed for S2AI screw placement. One issue with S2AI screws is that they sometimes need to be driven through the hard bone cortices of the SI joint with a power drill.

Post-operative care:

Before leaving the operating room following recovery, each patient underwent a neurological examination. They were also all given 3rd generation Cephalosporin (Cefotaxime 1 gm every 12 hours) for one week, and non-steroidal anti-inflammatory drugs were administered in accordance with each patient's tolerance. All patients used lumbar braces for two to three weeks before discarding them and being instructed to walk immediately post-op. However, for three months, patients are often not allowed to vigorous twist at the waist or lift more than five pounds. Limitations include prohibiting excessive exertion from stair climbing, pushing or pulling motions, lengthy sitting, and extended standing, all of which are typically only allowed for a period of 3-6 months.

Evaluation two weeks after surgery: The patients were examined for the removal of stitches and a clinical and neurological assessment. Follow-up: Follow-up was conducted after six weeks and three months. At each visit, the following things were assessed: Neurological testing was part of the clinical evaluation. Back pain, spinal movement, resumed employment, satisfaction, and problems. radiological evaluation, which may have included plain x-rays and a CT scan.

RESULTS

The Social Sciences Statistical Package, version 20.0, was used to analyze the data collected (SPSS Inc., Chicago, Illinois, USA). The mean and standard deviation of the quantitative values were displayed (SD). Frequency and percentages of data were used to express qualitative data.

The subsequent tests were conducted: The proportions between qualitative measures were compared using the Chi-square (x2) test of significance. When comparing two related samples, the paired sample t-test of significance was employed. The allowable margin of error was set at 5%, while the confidence interval was set at 95%. In light of the above, the p-value was deemed significant: likelihood (P-value) P-values under 0.05 were regarded as significant.

		Studied patients (N = 10)	
Sex	Male	5	50%
	Female	5	50%
Age (years)	Mean ±SD	45.8 ± 7.2	
	Min – Max	33 – 55	

Table (1): description of sex and age in all studied patients

The sex and age breakdown for each patient under study is shown in this table. The patients under study were split equally between 5 males and 5 girls in terms of sex. The average age of all the patients in the study was 45.8 7.2 years, with a minimum age of 33 and a maximum age of 55.

Studied patients (N = 10)		
Hospital stay (days)	Mean ±SD	4.8 ± 1.5
	Min – Max	3 – 8

Table (2): description of hospital stay in all studied patients

This table details each patient's hospital stay during the course of the study. The average hospital stay for all patients in the study was 4.8 +/- 1.5 days, with a minimum and maximum stay of 3 and 8 days, respectively.

Studied patients (N = 10)			
Screw position	Good position	7	70%
	Accepted position	2	20%
	Bad position	1	10%

Table (3): description of Screw position in all studied patients

This table shows the description of Screw position in all studied patients. It was good position in 7 patients (70%), accepted position in 2 patients (20%) and bad position in 1 patient (10%).

Studied patients (N = 10)			
Fusion level	L2-S2	2	20%
	L3-S2	3	30%
	L4-S2	5	50%

Table (4): description of fusion level in all studied patients

This table shows the description of fusion level in all studied patients. It was at L2-S2 in 2 patients (20%), L3-S2 in 3 patients (30%) and L4-S2 in 5 patients (50%).

Studied patients (N = 10)		
Post-operative VAS	Mean ±SD	3.9 ± 1.9
	Min – Max	2 – 7
Post-operative ODI	Mean ±SD	31.7 ± 19.2
	Min – Max	10 – 70

Table (5): description of post-operative VAS and ODI in all studied patients

This table shows the description of post-operative VAS and ODI in all studied patients. As regard post-operative VAS, the mean post-operative VAS of all studied patients was 3.9 ± 1.9 with minimum post-operative VAS of 2 and maximum post-operative VAS of 7. As regard post-operative ODI, the mean post-operative ODI of all studied patients was 31.7 ± 19.2 with minimum post-operative ODI of 10 and maximum post-operative ODI of 70.

		Pre-op (N = 10)	Post-op (N = 10)	T	P-value
VAS	Mean	8.1	3.9	6.4	< 0.001 HS
	±SD	0.7	1.9		
ODI	Mean	66.2	31.7	4.9	< 0.001 HS
	±SD	11.1	19.2		

T: independent sample T test.

HS: p-value < 0.001 is considered highly significant.

Table (6): comparison between pre-operative and post-operative (VAS & ODI) in studied patient

This table shows: Highly statistically significant (p-value < 0.001) decreased post-operative VAS (3.9 ± 1.9) when compared with pre-operative VAS (8.1 ± 0.7). Highly statistically significant (p-value < 0.001) decreased post-operative ODI (31.7 ± 19.2) when compared with pre-operative ODI (66.2 ± 11.1).

Studied patients (N = 10)		
VAS difference	Mean ±SD	4.2 ± 2.09
	Min – Max	1 – 7

Table (7): description of VAS difference in all studied patients

This table shows the description of VAS difference in all studied patients. The mean VAS difference of all studied patients was 4.2 ± 2.09 with minimum VAS difference of 1 and maximum VAS difference of 7.

Studied patients (N = 10)		
Follow up days	Mean ±SD	8.2 ± 3.2
	Min – Max	6 – 14

Table (8): description of follow up day in all studied patients

This table shows the description of follow up days in all studied patients. The mean follow up days of all studied patients was 8.2 ± 3.2 days with minimum follow up days of 6 days and maximum follow up days of 14 days.

DISCUSSION

The S2-alar-iliac (S2AI) screw route was described and clinically established at this point, putting an end to the hunt for alternate methods. There are several advantages to this method versus iliac screw placements. Due to diverging trajectories and in-line rod bending, lengthy screws can be pinched between the compact bone of the pelvis, allowing for minimal incisions. This is because it spans three cortical bone structures (the sacral bone and the SIJ). This study's

primary goal was to examine sacroiliac fixation in patients with sacroiliitis and L5 lythesis. The hospitals affiliated with Al-Azhar University hosted this prospective study. Ten patients with sacroiliitis and L5 lythesis participated in this investigation. Regarding the demographic information of the group under research, the current study revealed that there were 5 males and 5 females (50 percent each) among the patients.

The average age of all the patients in the study was 45.8 ± 7.2 years, with a minimum age of 33 and a maximum age of 55. Krieg et al's research, which can be used as evidence for the current investigation, sought to examine the results of patients who were treated using S2-alar-iliac (S2AI), S2-alar (S2A), and iliac (I) instrumentation as the most caudal level (S2AI-group included 18 patients, S2A-group included 20 patients and I-group included 22 patients). The mean age of the participants was 70.4 ± 8.5 years. The S2AI group included 50 women. Additionally, the groups under study had similar age and sex distributions.

The goal of the 2008 study by Luo et al. was to contrast the outcomes of iliac screw (IS) and S2 alar-iliac (S2AI) screw fixation techniques. 31 of the study's 111 subjects received S2AI fixation and 111 received IS. The S2AI group's participants had an average age of 65.2 years and 15.8 years, and 80.6% of them were female. The study groups also shared comparable patterns of ages and sexes. Additionally, Nakashima et al.'s analysis concentrated on the prevalence and risk factors for S2 alar-iliac (SAI) screw loosening following lumbosacral fixation, with a minimum follow-up of two years. The average age of the 35 patients included in this retrospective study—10 men and 25 women—was 72.88 ± 0 years. radiography data, especially spinopelvic measures, are affected by S2AI screws., was studied by Ishida et al., was published in Ishida et al. 46 patients received S2AI screws, whereas 17 patients received ISs. The S2AI group's mean age was 61.5 ± 10.7 years, with 67.4% of the participants being female. Additionally, age and sex were comparable throughout the groups under study. According to the current study, the average hospital stay for all patients was 4.8 ± 1.5 days, with a minimum and maximum stay of 3 and 8 days, respectively. However, Luo et al.,⁸ showed that there was no appreciable difference between the mean hospital stay in the S2AI group and the IS group, which was 19.1 ± 6.8 days.

While, Elder et al.,¹¹ reported that the mean hospital stay in S2AI group was 9.0 ± 7.0 days with no significant difference with IS group.

Also, Ishida et al.,¹⁰ reported that the mean hospital stay in S2AI group was 10.0 ± 7.9 days with no significant difference with IS group.

The great variation in hospital stay from study to another may be attributed to the differences in the studied age group, comorbidities and the incidence of operative complications.

Regarding Oswestry Disability Index score (ODI) and visual analog scale (VAS), the present study showed that the mean pre-operative VAS of all studied patients was 8.1 ± 0.7 with minimum pre-operative VAS of 7 and maximum pre-operative VAS of 9. As regard pre-operative ODI, the mean pre-operative ODI of all studied patients was 66.2 ± 11.1 with minimum pre-operative ODI of 44 and maximum pre-operative ODI of 78.

However, Luo et al.,⁸ reported that in S2AI group, the mean pre-operative VAS was (7.55 ± 3.12 for back and 7.31 ± 2.52 for leg) and the mean pre-operative ODI 48.24 ± 19.67. there was no

statistically significant difference between the S2AI and IS groups as regard preoperative VAS and ODI.

While, Elder et al.,¹¹ reported that in S2AI group, the mean pre-operative VAS was 5.5 ± 2.4. There was no statistically significant difference between the S2AI and IS groups as regard preoperative VAS.

Also, Ishida et al.,¹⁰ reported that in S2AI group, the mean pre-operative VAS was 5.5 ± 2.4. There was no statistically significant difference between the S2AI and IS groups as regard preoperative VAS.

As regard Screw position in all studied patients the current study showed that it was good position in 7 patients (70%), accepted position in 2 patients (20%) and bad position in 1 patient (10%).

Also, regarding fusion level in the studied patients the present study revealed that it was at L2-S2 in 2 patients (20%), L3-S2 in 3 patients (30%) and L4-S2 in 5 patients (50%).

However, Luo et al.,⁸ reported that in S2AI group, there were 6.5% have L1/2 fusion level, 87% have L2/3, 93.5% have L3/4, 97% have L4/5 and 97% have L5/S1. There was no statistically significant difference between the S2AI and IS groups as regard Interbody fusion level.

Depending on the lower fusion level, there might be variations in the occurrence of SIJP. A hypothetical situation states that L5-S can be buffered when the lower fusion level is at L5., but when it is below the sacrum, there is no cushion and the sacroiliac joint is put under a lot of stress (SIJ). This has been supported by prior reports of evidence¹².

As regard post-operative VAS, the mean post-operative VAS of all studied patients was 3.9 ± 1.9 with minimum post-operative VAS of 2 and maximum post-operative VAS of 7. As regard post-operative ODI, the mean post-operative ODI of all studied patients was 31.7 ± 19.2 with minimum post-operative ODI of 10 and maximum post-operative ODI of 70.

However, Luo et al.,⁸ reported that in S2AI group, at 3 months postoperatively the mean VAS was (3.19 ± 1.14 for back and 3.32 ± 1.84 for leg) and the mean ODI 17.96 ± 1.43. There was no statistically significant difference between the S2AI and IS groups as regard 3 months VAS and ODI.

While, Elder et al.,¹¹ reported that in S2AI group, the mean post-operative VAS was 2.8 ± 2.3. There was no statistically significant difference between the S2AI and IS groups as regard preoperative VAS.

Also, Ishida et al.,¹⁰ reported that in S2AI group, the mean post-operative VAS was 3.1 ± 2.6. There was no statistically significant difference between the S2AI and IS groups as regard preoperative VAS.

In the current study, we discovered that the post-operative VAS (3.9 ± 1.9) was significantly lower than the pre-operative VAS (8.1 ± 0.7) (p-value 0.001). Additionally, the post-operative ODI (31.7 ± 19.2) was significantly lower than the pre-operative ODI (66.2 ± 11.1) (high statistical significance; p-value 0.001). This was in agreement with Luo et al.,⁸ who revealed that both VAS score for back and leg and ODI were significantly improved in S2AI group. Also, Elder et al.,¹¹ revealed that VAS score

as well as ambulatory status was significantly improved in S2AI group.

As well, Ishida et al.,¹⁰ reported that VAS score as well as ambulatory status was significantly improved in S2AI group.

Additionally, Krieg et al findings 's match our findings in that more patients in the S2AI group reported relief in SIJ pain at maximum FU (S2AI 61.1 percent, S2A 25.0 percent, and I 22.7 percent of patients; $p = 0.02$) as opposed to after three months.

The mean VAS difference of all studied patients was 4.2 ± 2.09 with minimum VAS difference of 1 and maximum VAS difference of 7.

This was in agreement with Luo et al.,⁸ who revealed that in S2AI group the mean difference VAS of back were 4.46 and for leg were 3.99.

Also, Ishida et al.,¹⁰ reported that in S2AI group the mean difference VAS was 2.6 ± 2.0 .

As well, Elder et al.,¹¹ reported that in S2AI group the mean difference VAS was 2.5 ± 2.8 .

Furthermore, the meta-analysis by Gao et al.,¹³ reported that in S2AI group the mean difference VAS was 2.52.

The present study revealed that the mean follow-up days of all studied patients was 8.2 ± 3.2 days with minimum follow up days of 6 days and maximum follow up days of 14 days.

According to Krieg et al study, 's 7, all patients successfully completed a 3-month follow-up, and the mean follow-up time was 2.5 1.5 years ($p = 0.38$). Additionally, Ilyas et al.,¹⁴ revealed that the S2AI group's average follow-up period was 3.6 years (22.3 months). Additionally, according to Luo et al⁸ 's study, the average follow-up period lasted 32.3 months. The average follow-up length following surgery was 31.8 5.5 months, according to Nakashima et al. Additionally, Ishida et al paper 's from 2010 said that the average follow-up time was 21.1 months. The mean follow-up length for the S2AI group was 21.110.9 months, according to Elder et al.

CONCLUSION

Sacroiliac fixation was safe and efficient in the treatment of patients with sacroiliitis associated with L5 lythesis. Currently, one of the most widely used methods for spinopelvic fusion is S2AI screw fixation. Significantly fewer clinical and radiographic problems are linked to the S2AI method. We need further comparison research with larger sample sizes and longer follow-ups to corroborate our findings and pinpoint the risk factors for unfavourable outcomes.

Conflict of interest : none

REFERENCES

- Bernard TN, Kirkaldy-Willis WH. Recognizing specific characteristics of nonspecific low back pain. *Clin Orthop*. 2009; (217):266–80.
- Schwarzer AC, Aprill CN, Bogduk N. The sacroiliac joint in chronic low back pain. *Spine*. 2010;20(1):31–7.
- Maigne JY, Aivaliklis A, Pfefer F. Results of sacroiliac joint double block and value of sacroiliac pain provocation tests in 54 patients with low back pain. *Spine*. 2017; 21(16):1889–92
- Irwin RW, Watson T, Minick RP, Ambrosius WT. and Gender Differences in Sacroiliac Joint Pathology. 2007; 86(1):37–44. doi: 10.1097/PHM.0b013e31802b8554.
- Chang TL, Sponseller PD, Kebaish KM, Fishman EK. Low profile pelvic fixation: anatomic parameters for sacral alar-iliac fixation versus traditional iliac fixation. *Spine (Phila Pa 1976)*. 2009; 34(5):436–40.
- Hasan MY, Liu G, Wong HK, Tan JH. Postoperative complications of S2AI versus iliac screw in spinopelvic fixation: a meta-analysis and recent trends review. *Spine J*. 2020; 20(6):964–72.
- Krieg SM, Sollmann N, Ille S, Albers L, Meyer B. Revision by S2-alar-iliac instrumentation reduces caudal screw loosening while improving sacroiliac joint pain—a group comparison study. *Neurosurgical Review*. 2021; 44(4), 2145-51.
- Luo Q, Kim YC, Kim KT, Ha KY, Ahn J, Kim SM, Kim MG. Comparison of Radiographic And Clinical Outcomes Observed After Adult Spinal Deformity Correction Using Iliac Screw Versus S2-Alar-Iliac Screw. 2021; 987-8.
- Nakashima H, Kanemura T, Satake K, Ito K, Ishikawa Y, Ouchida J, et al. The prevalence and risk factors for S2 alar-iliac screw loosening with a minimum 2-year follow-up. *Asian Spine Journal*. 2020; 14(2), 177.
- Ishida W, Elder BD, Holmes C, Lo S, Goodwin CR, Kosztowski TA, et al. Comparison between S2-alar-iliac screw fixation and iliac screw fixation in adult deformity surgery: reoperation rates and spinopelvic parameters. *Global Spine Journal*, 2017; 7(7), 672-80.
- Elder BD, Ishida W, Lo S, Holmes C, Goodwin CR, Kosztowski TA, et al. Use of S2-alar-iliac screws associated with less complications than iliac screws in adult lumbosacropelvic fixation. *Spine*. 2017; 42(3), E142-E9.
- Unoki E, Miyakoshi N, Abe E, Kobayashi T, Abe T, Shimada Y. Sacroiliac joint pain after multiple-segment lumbar fusion: a long-term observational study-Non-fused sacrum vs. fused sacrum. *Spine Surgery and Related Research*. 2017; 1(2), 90-5.
- Gao Z, Sun X, Chen C, Teng Z, Xu B, Ma X, et al. Comparative radiological outcomes and complications of sacral-2-alar iliac screw versus iliac screw for sacropelvic fixation. *European Spine Journal*. 2021; 30(8), 2257-0.
- Ilyas, H, Place, H, & Puryear, A. A comparison of early clinical and radiographic complications of iliac screw fixation versus S2 alar iliac (S2AI) fixation in the adult and pediatric populations. *Journal of Spinal Disorders and Techniques*. 2015; 28(4), E199-E205.