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Outcomes of Low Versus High Density All Pedicle Screw Technique in Adolescent Idiopathic Scoliosis a Prospective Study

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Abstract

Recent studies have shown that pedicle screw insertion in adolescent idiopathic scoliosis (AIS) has the risk for causing injury not only to the nervous system but also to the surrounding viscera, which include the aorta, azygos vein, and esophagus. However, many consider Thoracic pedicle screw (TPS) constructs the standard of care for deformity correction. Several previous studies have demonstrated the advantage of pedicle screws in absolute and percent of curve correction in scoliotic curves compared with hook and wire constructs. Bilateral placement of pedicle screws at every level has commonly been used, and the method provides maximal rigidity to the scoliosis construct; however, it is possible that fewer screws are adequate. This is a prospective study including twenty patients of adolescent idiopathic scoliosis at the age ranging from 12 to 18 years at the time of surgical intervention all of them were managed by posterior spinal fusion all pedicle screw technique divided in two groups one group by high density technique and one by low density technique. The implant density was defined as the number of screws per spinal level fused. Patients will be divided into two groups according to the average implant density for the entire study. The low density (LD) group (n = 10) will have less than 1.61 screws per level, while the high density (HD) group (n = 10) will have more than 1.61 screws per level. All operations have been done at Al Zahraa University Hospital and Misr children's hospital for health insurance. This study shows that there was no statistically significant difference in radiographic measurements between high density and low density at final follow up (after 2 years). This study prospectively compared low density with high density pedicle screw instrumentation in terms of the clinical, radiological and SRS-22 outcomes in AIS. The two groups achieved satisfactory deformity correction. However, the operating time and blood loss were reduced, and implant costs were decreased with the use of low screw density constructs. All pedicle screw posterior achieves significant improvement in deformity correction and quality of life using high density or low-density screw pattern without significant loss of correction in follow up.

Keywords: Adolescent Idiopathic Scoliosis, Pedicle Screw, High density, Low density.

1. Introduction

Scoliosis is a common musculoskeletal disorder of the spine that is characterized by 3 Dimensions deformity of the spine, which produces direct effects on the thoracic cage. Previous studies have reported variable and indecisive high prevalence rates of scoliosis in children locally and globally. The prevalence of adolescent idiopathic scoliosis (AIS) ranges from 0.47% to 5.2%, with a higher rate and severity of spinal curvature in girls than in boys [1].

Surgical treatment for scoliosis is indicated in general, for a curve exceeding 45 to 50 degrees by the Cobb's method on the basis that:

1. Curves larger than 50 degrees progress even after skeletal maturity. Thoracic curves with a magnitude between 50 and 75 degrees at skeletal maturity (Risser IV or V) progressed by an average of 29.4 degrees over the 40.5 years follow-up period. Curves greater than 55 degrees at skeletal maturity (partial or total fusion of the iliac apophyses) progressed by more than 0.5 degrees per year. Thoracic curves with an average Cobb angle of 60.5 degrees progressed to 84.5 degrees over the 50 years follow up period.

2. Curves larger than 60 degrees cause loss of pulmonary function, and much larger curves cause respiratory failure. In patients with curves between 60 and 100 degrees, total lung capacity was 68% of the predicted normal values. Nearly half of the patients with thoracic curve greater than 80 degrees had shortness of breath, by an average age of 42 years. Vital capacity below 45% of the normal value and a Cobb angle greater than 110 degrees were risk factors to develop respiratory failure and earlier death.

3. Greater the curve progression, the more difficult it is to treat surgically, with more surgical anchors being necessary, duration of surgery prolonged, increased blood loss, and higher surgical complication rate [2].

Thoracic pedicle screw (TPS) instrumentation for adolescent idiopathic scoliosis (AIS) has gained popularity over the past two decades. Pedicle screws offer the advantage of three-column purchase of the vertebrae with higher pull-out strength and better rotational control. These biomechanical advantages have been translated into higher correction rates after scoliosis surgery. However, recent studies have shown that pedicle screw insertion in adolescent idiopathic scoliosis (AIS) has the risk for causing injury not only to the nervous system but also to the surrounding viscera, which include the aorta, azygos vein, and esophagus [3]. However, many consider TPS constructs the standard of care for deformity correction. Several previous studies have demonstrated the advantage of pedicle screws in absolute and percent of curve correction in scoliotic curves compared with hook and wire constructs [4]. Bilateral placement of pedicle screws at every level has commonly been used, and the method provides maximum rigidity to the scoliosis construct; however, it is possible that fewer screws are adequate. Decreasing implant density has the advantage of decreasing operative time, risk of screw malposition, and cost. These advantages need to be weighed in relationship to the ability to obtain and maintain correction. The optimal implant density remains unknown. Previous studies have shown that screw density does not matter regarding curve correction [5]. The use of fewer pedicle screws indicated a reduction in hospital expenses and risk of neurologic complications. If neurological complications or spinal cord injuries occur, the consequences could be disastrous [6].

2. Patients and Methods

This is a prospective study including twenty patients of adolescent idiopathic scoliosis at the age ranging from 12 to 18 years at the time of surgical intervention all of them were managed by posterior spinal fusion all pedicle screw technique divided in two groups one group by high density technique and one by low density technique. The implant density was defined as the number of fixation screws divided by the number of available anchor sites within the main curve [7] Patients will be divided into two groups according to the average implant density for the entire study. The LD group (n = 10) will have less than 1.61 screws per level (fig.1), while the HD group (n = 10) will have more than 1.61 screws per level (fig.2). All of the patients were operated at Al-Zahraa university hospital and Misr children's hospital for health insurance. Prior to beginning, the study was approved by the Research and Ethical Committees at the Faculty of Medicine for Girls Al-Azhar University. The parents and the patients (or the relevant attendants) of all participants were informed about the goal of the study and gave written consent for participation

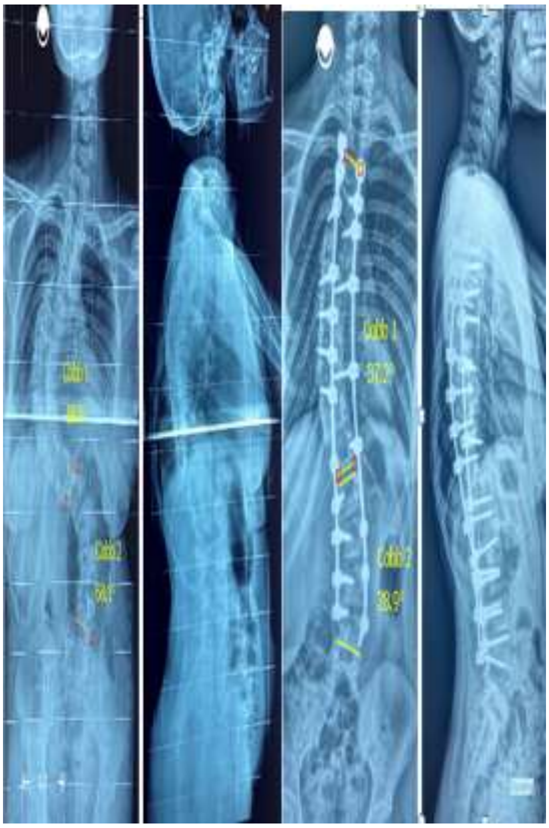
Patients were chosen according to the following criteria:

2.1 Inclusion Criteria

Children with adolescent idiopathic scoliosis age group from 10 to 18 years' old boys or girls. Patients were chosen to be in high density or low-density group randomly by the surgeon.

2.2 Exclusion Criteria

(1) Juvenile and infantile idiopathic scoliosis. (2) Other types of scoliosis (Neurogenic scoliosis or congenital scoliosis. (3) Previous spine surgery. (4) Cognitive dysfunction. (5) Any other co morbidities that could affect the quality of life. Posterior spinal fusion was done for all Patients through all pedicle screw technique in two groups (high density and low density). The preoperative, postoperative and latest follow-up after 24-month radiographic outcomes were analyzed with coronal and sagittal parameters. The perioperative outcomes and SRS-22r (scoliosis research society) Arabic version questionnaire scores were also compared between the two group's preoperatively as base line and at 2 years follow up). The patients were followed up for 2 years after surgery. They were available for clinical and radiological follow-up at regular visits (immediately postoperative, after two months, 6 months and then every 6 months till 24 months. All radiographs were measured twice preoperative, immediate postoperative and 2 years after surgery and the Scoliosis Research Society-22 questionnaire for patient-reported outcomes were collected from the patients and compared between the two groups.



a b c d

Fig. 1: A low-density pedicle screw construct was used. Preoperative standing anteroposterior (a) and lateral radiographs (b). Final follow-up standing anteroposterior (c) and lateral radiographs (d)

a b c d

Fig. 2: A high -density pedicle screw construct was used. Preoperative standing anteroposterior (a) and lateral radiographs (b). Final follow-up standing anteroposterior (c) and lateral radiographs (d)

2.3 Surgical technique.

Straight or curved in (severe curves) posterior skin incision using surgical knife following the spinous processes of the existing curve if severe one and straight if simple one from the preplanned upper instrumented vertebrae to the lower instrumented vertebrae. Following the course of the curve coagulation diathermy is used for Dissection of paraspinal muscles from the bone (working in the subperiosteal plane to minimize bleeding) and starting from very close to the spinous processes and going laterally towards the facets and transverse processes in the lumbar and thoracic regions with care to protect against penetration to the chest and putting gauze in the non-working area to help in hemostasis with care at the upper end trying to avoid injury to the supra and inter spinous ligaments to reduce the risk of proximal junctional kyphosis). Starting from the lower end vertebrae going up the facet joint and transverse process are clearly exposed. Always we started from the lumbar part of the curve and went up. Pedicle screw of proper size was inserted in the planned level and C-arm was used to ensure accurate positioning of the screws. After inserting all possible screws, we use the diathermy cable to measure the length of the rod. We usually do excision of spinous processes and inter spinous ligaments before rod insertion to help in correction except if there is bleeding in flexible curve, we delay this step and do it with decortication. The rod is then contoured according to the normal kyphotic thoracic curve and the lordotic lumbar curve. Correction is done after that using different reduction techniques (mostly we use rod derotation technique). Positioning of the rod in the screw heads is helped by using the rockers of different sizes without inducing much pulling forces on the screws to insert the nuts. This is followed by using inside benders to achieve maximum correction.

2.4 Radiographic, Perioperative and SRS-22 outcome Measurements.

Radiographic outcomes included assessments of the patients' Risser grade [8], convex-Bending Cobb angle, curve flexibility, thoracic and lumbar Cobb angle, thoracic kyphosis (T5-T12), lumbar lordosis (T1-L5), proximal junctional kyphosis, apical vertebral translation, and thoracic trunk shift in the preoperative, 2-week postoperative and final follow up periods. In addition, the change in the thoracic and lumbar Cobb angle and correction rate of the thoracic and lumbar curve were collected during the 2-week postoperative course and at final follow-up. Perioperative records were reviewed to determine the operating time, blood loss, blood transfusion, hospital stay, implant costs, number of fused levels, number of screws, cross-link number, and screw density. We also assessed the SRS-22 scores preoperatively and at final follow-up.

2.5 Statistical analysis:

Data was collected, coded, revised and entered to the Statistical Package for Social Science (IBM SPSS) version 20. The data were presented as number and percentages for the qualitative data, mean, standard deviations and ranges for the quantitative data with parametric distribution and median with inter quartile range (IQR) for the quantitative data with non-parametric distribution. *Chi-square test* was used in the comparison between two groups with qualitative data and *Fisher exact test* was used instead of the Chi-square test when the expected count in any cell found less than 5.*Independent t-test* was used in the comparison between two groups with quantitative data and parametric distribution and *Mann-Whitney test* was used in the comparison between two groups with quantitative data and non-parametric distribution the confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: P > 0.05: Non-significant (NS)P < 0.05: Significant (S)P < 0.01: Highly significant (HS).

3. Results

As show in table 1 twenty AIS patients were ultimately included in this study (LD: n = 10; HD: n = 10). In the LD group, there were 10 females, and the age at surgery was 15.4 ± 2.46 years. In the HD group, there were 10 females, and the age at surgery was 15 ± 1.76 years. Based on a comparison of these two groups, there was no significant difference in age, but there was significant difference in riser sign In the LD group the mean was (1.6) with SD (1.35). In the HD group it meant (4) with SD (1.05). As shown in table 2, regarding preoperative radiological parameters in two groups we compared thoracic and lumbar Cobb angle, convex-Bending Cobb angle, flexible index, apical vertebra translation, thoracic kyphosis, lumbar lordosis, and proximal junctional kyphosis. The baseline characteristics of the two groups are displayed in Table 2. There was no statistically significant difference between high density and low density among pre-operative radiological parameters. As shown in table 3, Perioperative measures of two groups are compared. Compared with the HD group, decreased operation time (130.1 vs. 155.5 min, p = 0.001), blood loss (397 vs. 655ml, p = 0.005), pedicle screws (18.2 vs. 22, p=0.012), screws density (1.39 vs. 1.81, p=0.001) were found in the LD group. As shown in table 4, as regards comparison between pre and postoperative radiological parameters in (HD) group (Table.4) there was statistically significant improvement (decrease) in Thoracic Cobb angle, Lumbar Cobb angle. Thoracic AVT, Lumbar AVT, and significant decrease in TK (t5-t12) and LL (T12-S1) in postoperative and significant increase in PJK. Fusing any spinal segment (whether short or long segment) affects the biomechanics of the spine, possibly leading to deleterious effects on the adjacent segments. And that may be the cause of increasing in PJK angle postoperative. As show in table 5, as regard comparison between pre and postoperative radiological parameters in (LD) group , there was statistically significant improvement (decrease) in Thoracic cobb angle, Lumbar cobb angle, TTS (mm), Thoracic AVT postoperative, and statistically significant decrease in TK(t5-t12) postoperative and statistically significant increase in PJK postoperative In spite of significant low density of the screws and screws number the low density group patients achieved significant improvement in radiological parameters compared to preoperative measurements. As shown in Tables 6,7 and 8 at final follow up, we compared immediate postoperative radiological parameters with the radiological parameters after two years in each group within the same group (HD) and (LD) and between both groups. In high density group there was no significant loss of correction (in thoracic and lumbar cob angle) in spite of in change of main thoracic cob angle there was some sort of loss of correction, but it didn't affect the correction rate after two years follow up period. In low density group after two years follow up there was no significant loss of correction in thoracic and lumbar cobb angle and there was significant improvement in change of main Thoracic cobb angle, change of main lumbar cobb angle, thoracic correction rate, Lumbar correction rate and Lumbar AVT. There was a significant difference in riser signs present between two groups as there was increase in riser signs in HD group. Postoperatively the rod can exert correction force on the spine as it tends to regain its original shape before being inserted to the spine so maybe the low-density group with riser sign less than high density group with more potential for growth has more malleability with this character. There was statistically significant decrease in Lumbar AVT in Final after 2 years in both groups that may be due to development of compensatory curve distal to the fused segment. As regards comparison between both groups in radiological parameters at final follow-up after two years there was no statistically significant difference between both groups. As shown in Table 9 SRS Questionnaire chosen to assess the functional status pre and postoperative at final follow up. In high density group there was a significant improvement in function, pain, self-image and satisfaction postoperative at final follow up. As shown in table 10 in low density group there was statistically significant improvement in function, pain, mental health, satisfaction and self-image postoperative at final follow up. As shown in table 11 when both groups compared there was statistically significant increase in Self-image and Satisfaction in high density group.

Table 1: Comparison between high density and low density among age and riser sign.

		High density final		Low density final		Independent t test	
		Mean	SD	Mean	SD	t	p value
Age		15.00	1.76	15.40	2.46	-0.418	0.681
Riser sign		4.00	1.05	1.60	1.35	4.431	0.001

Table 2: Comparison between high density and low density among pre-operative:

	High density		Low density		Independent t test	
	Mean	SD	Mean	SD	t	p value
Thoracic cobb angle	58.58	9.85	56.70	12.62	0.371	0.715
Lumbar cobb angle	43.39	6.87	49.23	10.18	-1.301	0.214
Thoracic convex bending cobb	43.13	12.22	51.43	20.93	-0.604	0.572
Lumbar convex bending cobb	39.20	0.00	36.63	11.66	0.191	0.866
Thoracic flexibility	25.00	13.11	13.45	4.46	1.683	0.153
Lumbar flexibility	22.00	0.00	28.00	1.73	-3.000	0.095
TTS (mm)	20.83	10.24	23.73	11.64	-0.592	0.562
Thoracic AVT	51.97	13.92	50.72	18.84	0.169	0.868
Lumbar AVT	31.04	6.23	22.96	10.56	1.768	0.101
TK (t5-t12	36.48	10.88	37.00	11.58	-0.103	0.919
LL(T12-S1)	58.45	11.25	58.26	12.74	0.035	0.972
PJK	5.31	1.75	5.55	1.44	-0.296	0.772

Table 3: Comparison between high density and low density among perioperative data.

	High density		Low density		Independent t test	
	Mean	SD	Mean	SD	t	p value
Blood loss	655.00	214.02	397.00	140.08	3.190	0.005
Blood transfusion	500.00	0.00	500.00	0.00	NA	NA
Operative time	155.50	14.99	130.10	8.25	4.694	0.001
Fused levels	12.10	1.79	13.10	0.57	-1.682	0.110
Number of screws	22.00	3.68	18.20	2.20	2.801	0.012
Screw density	1.81	0.12	1.39	0.13	7.542	0.001

Table 4: Comparison between pre and postoperative among radiographic measurements in high density group.

High density						
	Pre		Post		Parried t test	
	Mean	SD	Mean	SD	t	p value
Thoracic cobb angle	58.58	9.85	19.54	9.35	16.751	0.001
Lumbar cobb angle	43.39	6.87	12.13	7.49	12.343	0.001
TTS (mm)	20.83	10.24	13.19	15.39	1.050	0.324
Thoracic AVT	51.97	13.92	33.34	16.85	3.794	0.005
Lumbar AVT	31.04	6.23	16.56	10.03	4.211	0.006
TK (t5-t12	36.48	10.88	22.94	7.26	4.072	0.004
LL(T12-S1)	58.45	11.25	42.81	3.13	4.578	0.002
PJK	5.31	1.75	9.21	2.81	-6.165	0.001

Table 5: Comparison between pre and postoperative among radiographic measurement in low density group.

Low density						
	Pre		Post		Parried t test	
	Mean	SD	Mean	SD	t	p value
Thoracic cobb angle	56.70	12.62	21.37	8.99	8.770	0.001
Lumbar cobb angle	49.23	10.18	20.21	7.01	12.055	0.001
TTS (mm)	23.73	11.64	9.02	5.38	3.628	0.006
Thoracic AVT	50.72	18.84	28.03	13.38	9.293	0.001
Lumbar AVT	22.96	10.56	22.31	6.69	0.164	0.871
TK (t5-t12	37.00	11.58	27.00	7.95	3.062	0.014
LL(T12-S1)	58.26	12.74	60.89	15.62	-0.677	0.515
PJK	5.55	1.44	8.39	1.47	-4.233	0.004

Table 6: Comparison between postoperative and postoperative (final after 2 years) among radiographic measurements in high density.

High density						
	Post		Final after 2 years		Parried t test	
	Mean	SD	Mean	SD	t	p value
Thoracic cobb angle	19.54	9.35	21.21	9.42	0.872	0.408
Lumbar cobb angle	12.13	7.49	12.21	8.14	0.065	0.950
change of main Thoracic cobb angle	39.36	6.68	37.66	10.29	6.001	0.001
change of main lumbar cobb angle	31.18	7.37	31.08	9.01	8.640	0.001
Thoracic correction rate	67.41	12.02	63.94	16.00	0.548	0.592
Lumbar correction rate	72.43	15.15	71.94	17.63	0.066	0.947
TTS (mm)	13.19	15.39	14.78	9.74	0.506	0.626
Thoracic AVT	33.34	16.85	35.11	13.12	0.421	0.685
Lumbar AVT	16.56	10.03	13.36	9.78	-2.569	0.037
TK (t5-t12	22.94	7.26	27.89	9.49	2.191	0.060
LL(T12-S1)	42.81	3.13	47.16	8.35	1.503	0.171
PJK	9.21	2.81	9.99	3.44	1.376	0.211

Table 7: Comparison between postoperative and postoperative (final after 2 years) among radiological parameters in low density.

Low density						
	Post		Final after 2 years		Parried t test	
	Mean	SD	Mean	SD	t	p value
Thoracic cobb angle	21.37	8.99	18.82	8.67	0.872	0.408
Lumbar cobb angle	20.21	7.01	17.21	5.44	0.065	0.950
change of main Thoracic cobb angle	35.87	12.11	37.88	10.33	6.001	0.001
change of main lumbar cobb angle	29.01	7.20	32.02	6.42	8.640	0.001
Thoracic correction rate	62.73	14.26	66.89	12.12	-6.743	0.001
Lumbar correction rate	59.27	10.55	65.30	6.64	-9.487	0.001
TTS (mm)	9.02	5.38	13.41	7.21	0.506	0.626
Thoracic AVT	28.03	13.38	25.71	10.18	0.421	0.685
Lumbar AVT	22.31	6.69	20.47	6.17	-2.569	0.037
TK (t5-t12	27.00	7.95	29.73	10.18	2.191	0.060
LL(T12-S1)	60.89	15.62	52.33	13.17	1.503	0.171
PJK	8.39	1.47	11.09	5.47	1.376	0.211

Table 8: Comparison between high density and low density among final (post 2 years).

	High density final		Low density final		Independent t test	
	Mean	SD	Mean	SD	t	p value
Thoracic cobb angle	21.21	9.42	18.82	8.67	0.576	0.572
lumbar cobb angle	12.21	8.14	17.21	5.44	-1.505	0.153
Change of main Thoracic cobb angle	37.66	10.29	37.88	10.33	-0.047	0.963
Change of main lumbar cobb angle	31.08	9.01	32.02	6.42	-0.252	0.805
Thoracic correction rate	63.94	16.00	66.89	12.12	-0.455	0.655
lumbar correction rate	71.94	17.63	65.30	6.64	1.052	0.309
TTS (mm)	14.78	9.74	13.41	7.21	0.350	0.730
Thoracic AVT	35.11	13.12	25.71	10.18	1.755	0.097
Lumbar AVT	13.36	9.78	20.47	6.17	-1.883	0.078
TK (t5-t12	27.89	9.49	29.73	10.18	-0.406	0.690
LL(T12-S1)	47.16	8.35	52.33	13.17	-1.009	0.327
PJK	9.99	3.44	11.09	5.47	-0.495	0.627

Table 9: Comparison between SRS Questionnaire items pre and at final follow up in high density group.

High density SRS Questionnaire pre and at final follow up						
	Pre		Post		Parried t test	
	Mean	SD	Mean	SD	t	p value
Function	3.20	0.69	4.34	0.22	-4.076	0.007
Pain	3.16	0.99	4.29	0.58	-3.331	0.016
Mental health	3.40	0.89	4.26	0.93	-2.205	0.070
Satisfaction	2.00	0.00	4.85	0.2	-45.06	0.001
Self-image	2.25	1.13	4.62	0.26	5.778	0.001

Table 10: Comparison between SRS Questionnaire items pre and at final follow up in low density group.

Low density SRS Questionnaire pre and at final follow up						
	Pre		Post		Parried t test	
	Mean	SD	Mean	SD	t	p value
Function	3.24	0.74	4.29	0.32	-2.997	0.024
Pain	3.34	1.10	4.23	0.45	-2.624	0.039
Mental health	2.40	0.13	3.49	0.61	-4.340	0.005
Satisfaction	1.43	0.53	3.64	0.37	-7.750	0.001
Self-image	2	0.2	3.82	0.29	17.982	0.001

Table 11: Comparison between high density and low density among SRS Questionnaire postoperative at final follow up.

	High density final		Low density final		Independent t test	
	Mean	SD	Mean	SD	t	p value
Final follow up						
Function	4.34	0.22	4.29	0.32	0.385	0.707
Pain	4.29	0.58	4.23	0.45	0.206	0.840
Self-image	4.63	0.27	3.83	0.29	5.323	0.001
Mental health	4.26	0.93	3.49	0.61	1.837	0.091
Satisfaction	4.86	0.24	3.64	0.38	7.141	0.001

4. Discussion

Pedicle screw instrumentation has become a common treatment for AIS patients [9]. Previous studies have demonstrated that pedicle screws could achieve safe and effective correction of deformity compared with hybrid or hook constructs. Other potential benefits of pedicle screw constructs include higher pull-out strength, lower rate of implant failure, less long-term loss of correction, selective fusion, and lower pseudo arthrosis rates [10]. Kan Min • Christoph Sdzuy et al. [10] in long term10 years follow up prospective study found that the correction of thoracic AIS with thoracic pedicle screw instrumentation is a safe procedure. Insertion of screws in every single vertebra is not necessary as a satisfactory multi-dimensional radiological correction, and a high long term patient's satisfaction can be achieved with a low implant density of average 1 screw per vertebra (50 %) [10]. Previous studies have investigated the relationship between the implant density and correction of AIS patients. Mac-Thiong et al. reported that adding fixation screws (an implant density of ≥70% in the main curve) was unlikely to result in significantly greater coronal correction of the main curve in posterior AIS surgery [11]. Li et al. found that a limited pedicle screw construct was equal to a consecutive screw construct in a randomized study, and there were no significant differences in the correction of the coronal and sagittal planes in Lenke 1 curves [12]. Kemppainen et al. reviewed 52 AIS patients with more than 2 years of follow-up and found that fewer screws not only achieved excellent curve correction, stability, and balance but also reduced the operative time and decreased the cost and risk [13]. Hosseini et al. published a study that used a series of 21 female patients who were treated with a lower implant density construct, achieving and maintaining a similar AIS correction as with current posterior fusion techniques (14). In addition, Wang et al. used a three-screw density pattern (low, preferred, and high screw density) in scoliosis patients and reported that there were no statistically significant results in terms of the curve correction or bone-screw force levels via biomechanical analysis [15]. In our prospective comparative study, we found that postoperative there is significant improvement in thoracic cob angle in both groups (high and low density) in lenke 1 patient and in both thoracic and lumbar cobb angle in lenke type 3 patient. The high-density group results show that there was statistically significant decrease in thoracic cobb angle from the mean (58.58) with standard deviation (9.85) preoperative to mean (19.54) with standard deviation (9.35) Postoperative. Also, there was statistically significant decrease in the lumbar Cobb angle from the mean (43.39) with standard deviation (6.87) preoperative to mean (12.13) with standard deviation (7.49) postoperative. Moreover, the low-density group shows that there was statistically significant decrease in thoracic Cobb angle from the mean (56.70) with standard deviation (12.62) preoperative to mean (21.37) with standard deviation (8.99) postoperative. And there was statistically significant decrease in the lumbar cobb angle from the mean (49.23) with standard deviation (10.18) preoperative to mean (20.21) with standard deviation (7.01) postoperative. At final follow up there was no statistically significant difference in the lumbar cobb angle between two groups as in high density group the mean was (12.12) with standard deviation (8.14) compared to the low-density group mean (17.21) with standard deviation (5.44) and that there was statistically significant decrease in Lumbar AVT in final follow up after 2 years follow up. When comparing changes in main thoracic cobb angle and main lumbar cobb angle and thoracic correction rate and lumbar correction rate at final follow up between two groups there was no statistically significant difference. There is significant improvement in thoracic apical vertebral translation (AVT) and lumbar (AVT) in both groups post op and at final follow up. In high density thoracic (AVT) the mean was (51.97) with standard deviation (13.92) preoperative compared to mean (33.34) with standard deviation (16.85) postoperative and at final follow up the mean was (35.11) with standard deviation (13.12). In low density thoracic (AVT) the mean was (50.72) with standard deviation (18.84) preoperative compared to mean (28.03) with standard deviation (13.38) postoperative and at final follow up the mean was (25.71) with standard deviation (10.18) that may be due to development of compensatory curve distal to the fused segment and there was statistically significant improvement in thorathic and lumbar cobb angle and thoracic and lumbar correction rate. Furthermore, at final follow up after two years no significant difference between two groups in all radiographic parameter's coronal or sagittal. Oliver et al published a prospective study to evaluate effectiveness and Cost of Low-Density Pedicle Screw Constructs for adolescent idiopathic scoliosis: in Forty-five patients were identified after operative data base query. Ten patients had incomplete radiographic history and were excluded, leaving 35 cases for analysis. The mean patient age at the time of surgery was 14.9 years (range12-19 years), with 28 female and 7 male patients. Of the 35 cases, 23 had Lenke type 1 curves, 6 had type 3, 2 had type 2,2 had type 4, and 2 had type 5.and he found that the mean preoperative major Cobb angle measurement among the 3 observers was 52.6_ (curve range 41_ to 80_). The mean percent major curve correction was 71.2% at initial postoperative follow-up and 66.9% at latest follow-up. Lumbar fractional curves improved from a mean of 35.6_ preoperatively to a mean of 10.6_ (70% correction) at initial follow-up and 12.9_ (63% correction) at final follow-up., the cost of all pedicle screws is $1000 per screw, and the cost of a cross link is $750. In their cohort of 35 patients, they placed a total of 468 screws and 70 cross links (2 cross links per construct). The total implant cost was $520 500, or an average of $14 871 per patient, excluding the cost of the rods. Assuming an HD construct with 2 screws per level, the cost of their cohort with an HD model would amount to $834 500 ($782 000 for the screws and $52 500 for the cross links), or an average of $23 840 per case. In this cohort of 35 patients, they obtained savings of $314 000 in implant costs, almost $9000 per patient (16). In our study there was significant difference in number of screws between two groups that made low density group saving more money than high density group. In high density the mean screw density was (1.81) with standard deviation (0.12). In low density the mean screw density was (1.39) with standard deviation (0.13). Liu et al. evaluated 77 Lenke type 1 AIS patients who underwent single-stage posterior correction and instrumented spinal fusion with pedicle screw fixation; they found that a high screw density on the concave side could provide better outcomes with respect to sagittal TK restoration [17]. Sudo et al. analysed 64 Lenke 1 AIS patients who were treated with posterior correction and fusion surgery, demonstrating that changes in thoracic kyphosis were positively correlated with the screw's density at the concave side (r = 0.351, p = 0.036), which was not the case on the convex side (r = 0.144, p = 0.40) [18]. In our finding postoperative high-density group shows that there was statistically significant decrease in TK (t5-t12) from the mean (36.48) with standard deviation (10.88) preoperative to mean (22.94) with standard deviation (7.26) Postoperative. Also, in low density group shows that there was statistically significant decrease in TK (t5-t12) from the mean (37) with standard deviation (11.85) preoperative to mean (27) with standard deviation (7.95) post op. And there was no statistically significant difference between the two groups postoperative.

Also, at final follow up there was no statistically significant difference between two groups. High density group TK from (t5-t12) the mean (22.94) with standard deviation (7.26) and low-density group mean (27.00) with standard deviation (7.95). There was statistically significant increase in PJK. In high density group from the mean (5.31) with standard deviation (1.75) preoperative to mean (9.21) with standard deviation (2.81) Postoperative. There was statistically significant increase in PJK. In low density group from the mean (5.55) with standard deviation (1.44) preoperative to mean (8.39) with standard deviation (1.47) Postoperative. Fusing any spinal segment (whether short or long segment) affects the biomechanics of the spine, possibly leading to deleterious effects on the adjacent segments. And that is may be the cause of increasing in PJK angle postoperative. But there was no statistically significant difference in PJK between two groups postoperative or at final follow up and there was no statistically significant difference within the same group when comparing postoperative and final follow up [19]. Neural complications in the surgical treatment of AIS could not be ignored. Diab et al. reviewed 1301 consecutive surgical cases of AIS and reported that the overall neurological complication rate was 0.69% [20]. A systematic review analysed 13,536 pedicle screws placed in 1353 paediatric patients, and the overall placement accuracy rate was 94.9%. When adding more screws to the construction, the occurrence of neurological complications increased [21]. Timothy J. Skalak et al. [22] in prospective study with level 3 evidence questioned whether higher screw density constructs improved curve correction and maintenance of correction in Lenke 2 AIS. Secondary goals were to identify predictive factors for correction and postoperative magnitude of curves in Lenke 2 AIS. And they concluded that neither anchor nor implant density were associated with major or minor curve magnitude or thoracic kyphosis at 2-year follow-up after posterior spinal fusion for Lenke 2 AIS. Factors that appear to predict postoperative major curve magnitude and percent major curve correction are female sex, preoperative major curve magnitude, and age at time of surgery. In an era of cost-conscious medical care, the ideal implant density for achieving and maintaining curve correction while minimizing cost and exposure of the patient to the potential risks of screw malposition remain to be clarified. Moreover, the minimal clinically important difference for change in radiographic parameters is currently unknown. This study supports the use of lower implant density constructs in the surgical treatment of Lenke 2 AIS. Further studies are needed to ascertain the ideal implant density to achieve maximal radiographic- and patient-reported outcomes [22]. In a long term prospective study of surgical results of skip pedicle screw fixation for patients with adolescent idiopathic scoliosis: A minimum-ten-years follow-up Masashi Uehara, Shugo Kuraishi et al found that Skip pedicle screw fixation for adolescent idiopathic scoliosis (AIS) requires fewer screws and can reduce the risk of neurovascular injury as compared with segmental pedicle screw fixation however, the long-term impact of screw number reduction on correction and clinical results is unclear. This study examined the 10-year post-operative outcomes of skip pedicle screw fixation for patients with AIS. They reviewed the outcomes of 30 patients who underwent skip pedicle screw fixation for AIS. Radiological and clinical findings were assessed before and immediately, 2 years, and 10 years after surgery in the remaining 25 patients. The mean Cobb angle of the main curve preoperatively and immediately, 2 years, and 10 years post-operatively was 59.4_, 23.4_, 25.8_, and 25.60_, respectively, and was significantly improved at all post-surgical time points (all $p < 0.001$). The mean correction rate immediately after surgery was 60.8%, and the correction loss rate at the observation end point was 4.8%. The Cobb angle of the lumbar curve was significantly improved immediately after surgery, and the correction persisted until 10 years post-operatively [23]. In our study there is no neural complications in both low density and high-density groups. In prospective study by Mingkui Shen1, et al comparing low density and high-density pedicle screw instrumentation in Lenke 1 adolescent idiopathic scoliosis in term of perioperative data they found that decreased operation time in low density (278.4 compared to. 331.0 min, in high density $p = 0.004$), decreased blood loss (823.6 vs. 1010.9 ml in high density, $p = 0.048$), decreased pedicle screws (15.1in low density vs. 19.6, in high density $P<0.001$), and decreased implant costs ($10,191.0 in low density vs. $13,577.3, in high density $p = 0.003$). However, no significant differences were detected in the hospital stays (18.7 vs. 19.9, $p = 0.16$) and cross-link numbers (0.6 vs. 0.3, $p = 0.06$) [24]. In our study there was statistically significant increase Blood loss and operative time in high density group. Blood transfusion was not applicable but three cases in the high-density group need blood transfusion and only one case in the low-density group need blood transfusion and there was statistically significant increased Number of screws and Screw density in high density with no difference in hospital stay as it was almost two days in both groups. In the term of comparing the SRS-22 questionnaire of the two groups between preoperative and at final follow up in high density there was statistically significant improvement in function, pain, self-image and satisfaction postoperative at final follow up. In low density there was statistically significant improvement in function, pain, mental health, satisfaction and self-image at final follow up.

Summary and Conclusion. This study prospectively compared low density with high density pedicle screw instrumentation in terms of the clinical, radiological and SRS-22 outcomes in AIS. The two groups achieved satisfactory deformity correction. However, the operating time and blood loss were reduced, and implant costs were decreased with the use of low screw density constructs. All pedicle screw posterior achieves significant improvement in deformity correction and quality of life using high density or low-density screw pattern without significant loss of correction in follow up. Inspite of the blood transfusion item was statistically not applicable 3 cases need blood transfusion in the high-density group compared to one case in the low-density group which means that the high-density group need more blood transfusion. There was no neurological complication in both groups which support that the all-pedicle screw technique is safe method for deformity correction especially adolescent idiopathic scoliosis. The limitations of this study are small sample size and not all patients at the same lenke group but preoperatively there is no statistically significant difference in radiographic measurements between two groups and almost the patients in both groups are falling in lenke type 1 and lenke type 3.

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