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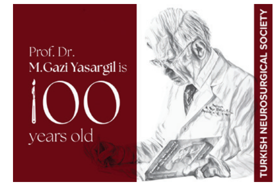

Systematic Review

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Does Hybrid Instrumentation Using Sublaminar Bands Give Comparable Results to All Pedicle Screw Constructs in Surgical Correction of Adolescent Idiopathic Scoliosis? A Systematic Review and Meta-Analysis of Current Evidence

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ABSTRACT

AIM: To compare the results of surgical correction of adolescent idiopathic scoliosis (AIS) by posterior instrumentation using the conventional all pedicle screw fixation method (PS) and the hybrid fixation method utilising the sublaminar bands along with pedicle screws (HG).

MATERIAL and METHODS: The study adheres to Preferred Reporting Items for Systematic reviews and Meta Analysis (PRISMA) and was registered with PROSPERO. This review included studies conducted on patients having AIS. All studies comparing the outcomes of PS with HG were included.

RESULTS: We found an improvement of the main curve (p=0.007; SMD (IV, Random) = 0.54; 95% CI [0.15, 0.93]) in the PS group to be statistically significant. The two groups had statistically insignificant differences in the operative time, blood loss, number of levels fused, secondary curve correction and complication rates. We found PS had better outcomes in cases with preoperative hyperkyphosis whereas HG was better for patients with preoperative hypokyphosis. The complications on ling term follow up in the form of distal junctional kyphosis 2 years after surgery is higher in PS (5%).

CONCLUSION: Hybrid constructs using sublaminar bands along with pedicle screws are safe and effective option for posterior instrumentation of AIS due to reduced incidence of complications like distal junctional kyphosis. They give better deformity correction in sagittal planes hence are more effective in restoring the dorsal kyphosis post-operatively.

KEYWORDS: Adolescent idiopathic scoliosis, Posterior instrumentation, Pedicle screws, Hybrid fixation and sublaminar bands

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is the most common type of pediatric scoliosis with an overall prevalence of 0.47%–5.2% and age-adjusted and sex-adjusted annual incidence of 522.5 per 100000 persons-years (12,27). It occurs generally after the age of 10 years and females are affected more than males. AIS curves are commonly right sided curves (3,27,29). A primary curve of more than 45° in skeletally immature patients usually requires surgical correction because it tends to progress rapidly and is cosmetically worrisome for the patient (16).

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Currently, posterior instrumentation with fusion of vertebrae is preferred over other approaches because of superior construct rigidity and excellent deformity correction achieved with least complications among all the approaches (17,29). Nowadays posterior instrumentation is done using either all-pedicle screws system or a hybrid fixation system comprising of pedicle screws in middle segments and hooks, sublaminar wires or bands in the proximal and distal segments either alone or in combination (14,24). The aim of this review is to compare the surgical outcomes of surgical correction by posterior instrumentation in patients of AIS using all-pedicle screws system (PS) and hybrid fixation method using sublaminar elastic bands along with pedicle screws (HG). The review aims to establish the effectiveness of the above said hybrid fixation system against the conventional all pedicle screw system.

MATERIAL and METHODS

Study Details

The study follows the Preferred Reporting Items for Systematic reviews and Meta Analysis (PRISMA) (Figure 1). The protocol has been registered in PROSPERO (registration ID CRD42022367999). Search for relevant articles as per the study question was conducted by two authors (SB, VR) online in PubMed, Scopus, Embase and Web of Science databases. The keywords used for the search were “adolescent idiopathic scoliosis”, “posterior instrumentation”, “pedicle screws”, “hybrid fixation” and “sublaminar bands”. Appropriate Boolean operators were used as applicable and the recommended search guidelines for the specific database were followed. The search results were exported to spreadsheets (Microsoft Excel, USA) and the duplicate articles were removed. Preliminary screening of the study titles and abstracts was done to find the relevant articles by two authors (SB, VR). Full text of the selected articles were read to decide on their final eligibility. Any disagreement among the two authors on the eligibility was resolved by the intervention of the two senior authors (VK, AJV).

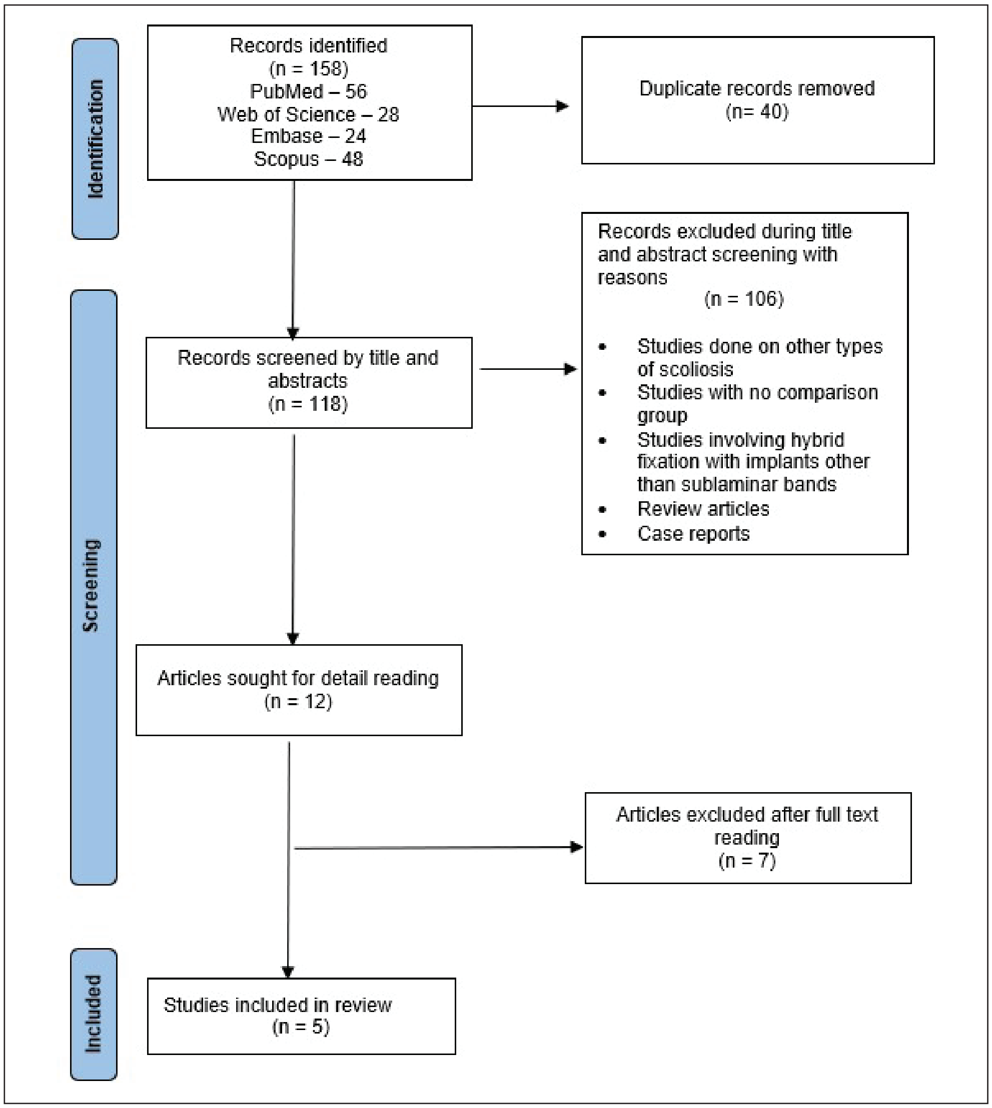

Figure 1: PRISMA flowchart.

Eligibility Criteria

This review included studies conducted on patients having AIS. The studies which described surgical corrections by posterior instrumentation in AIS patients and compared the use of all pedicle screws fixation system (PS) with hybrid fixation system using sublaminar bands along with pedicle screws (HG) were included in the review. No filter based on the type of study, study period, age of the subjects and minimum follow up period was set during the search. Case reports, review articles, letter to editors, conference papers and articles in other than English language were excluded. We also excluded studies dealing with any non-surgical treatment, biomechanical studies and brief communications. Studies done on animal subjects or cadaveric studies were also excluded. Screening of the bibliography of all the included studies as well as previously published systematic reviews was done to look for any additional study eligible for inclusion. Any dispute with regards to inclusion of the studies was resolved by discussion with the senior authors (VK, AJV).

Quality Assessment

All the articles found eligible based on the inclusion and exclusion criteria were assessed by two authors (VK, AJV) independently for their using the MINORS tool (Methodological Index for Non-Randomised Studies) and the risk of bias was assessed (Table I) (23). MINORS tool can be used to assess both comparative and non-comparative studies. It has a total score of 24 for comparative studies (12 items) and 16 for non-comparative studies (8 items). The checklist awards point (a maximum of 2 and minimum of 0) to each of the following questions: 1) a clearly stated aim, 2) inclusion of consecutive patients, 3) prospective collection of data, 4) endpoints appropriate to the aim of study, 5) unbiased assessment of study end point, 6) follow up period appropriate to aim of study, 7) attrition of less than 5% and 8)prospective calculation of study size. Additionally for comparative studies, the checklist includes items like 9) adequacy of the control group, 10) contemporariness of the groups, 11) equivalence of the groups and 12) adequacy of the statistical analysis.

Data Extraction

Data extraction was done independently by three authors (VR, SB, R) using a pre-decided spreadsheet prepared by the senior authors (VK, AJV) by scrutinizing the full text of the included studies. Demographic data in the form of type of study, study period, sample size, age at surgery, gender ratio of the study participants, Lenke classification of AIS, mean follow up period and data on kyphosis were recorded (Table I). The operative data in the form of mean operative time, blood loss, upper instrumented vertebra level, lower instrumented vertebra level, implant density, number of vertebrae fused, average hospital stay and details of complications were extracted (Table II). The pre-operative data, post-operative data and the data at final follow up regarding primary Cobb angle, secondary Cobb angle, Tertiary Cobb's angle, lumbar lordosis, thoracic hyperkyphosis, thoracic hypokyphosis, sagittal balance, coronal balance, pelvic inclination and pelvic obliquity were extracted to compare PS with HG using sublaminar bands (Table III).

Statistical Analysis

Mean, standard deviation, percentages and ranges were used to describe the data collected. RevMan (Cochrane.org, UK) software was used for meta-analysis. Comparative studies included in the review were assessed using a formal meta-analysis using Der Simonian Laird method (5) with the random effect model. The correction of the primary Cobb angle, secondary Cobb angle, tertiary Cobb angle, lumbar lordosis, thoracic hyperkyphosis, thoracic hypokyphosis, sagittal balance, coronal balance, pelvic inclination and pelvic obliquity were compared across all the included studies and the amount of correction achieved was calculated using an observational meta-analysis. The I2 statistic was used to assess the heterogeneity among the included studies (8). Low, moderate and high level of heterogeneity is denoted as per I2 values of 25%, 50% and 75% respectively. A p value <0.05 was taken to be statistically significant for the overall effect of Z test. Sensitivity analysis was done by exclusion of studies to identify the study contributing to the heterogeneity. Narrative review of the data that cannot be statistically analysed was done.

RESULTS

Literature Search

The initial search gave 156 results (Figure 1). After removal of duplicates, we had 118 articles for preliminary titles and abstract screening. We excluded 106 of them because of various reasons including studies done on scoliosis other than AIS, studies having no comparison, studies done on HG system with implants other than sublaminar bands, case reports, cadaveric studies and review articles. A total of 12 studies were selected for full text screening, and 5 of the studies finally included in the systematic review (4,13,18,19,22).

Study Characteristics

All the studies included except one were retrospective comparative studies (18) comparing the results of PS and HG in AIS patients undergoing surgery by posterior instrumentation. Except Sikora-Klak et al. all the other authors included consecutive patients in their study design (22). Unbiased assessment of the study endpoints was reported by two of the included studies (4,13). All the studies except one reported baseline equivalence among the two groups of the study subjects (Table II) (18). The heterogeneity (I^2) across the studies ranged from 0 to 95%.

Table I: Demographic Data

Study No	Author & Year	Study Type	Study Period	Sample Size (N)	Groups	No. of patients (n)	Mean Age (in years)	Gender (M:F)	Average Follow Up (in months)	Lenke Classification	Primary Scoliotic Curve (in °)	Global flexibility (in °)	Sagittal plane deformity
1	La Maida et al. (2018), (13)	Retrospective comparative study	January 2011 to December 2015	81	AS	36	15.7 ± 1.9	22:59	24	-	-	-	-
					SB	45	15.3 ± 2.4						
2	Palmisani et al. (2018), (18)	Prospective Comparative study	-	37	AS	18	14.3	17:20	24	Lenke type 1 – Modifier A – 10/18 (55.6%) Modifier B – 6/18 (33.3%) Modifier C – 2/18 (11.1%)	-	-	Hypokyphosis – 7/18 Normal Kyphosis – 10/18 Hyperkyphosis – 1/18
					SB	19	13.8			Lenke type 1 – Modifier A – 9/19 (47.4%) Modifier B – 6/19 (31.6%) Modifier C – 3/19 (15.8%)	-	-	Hypokyphosis – 10/19 Normal Kyphosis – 6/19 Hyperkyphosis – 3/19
3	Cinnella et al. (2019), (4)	Retrospective comparative study	January 2010 to December 2016	27	PSG	15	16 ± 1.56	5:10	60.93 ± 22.82	Lenke type 1 – 17/27 (63%) Lenke type 2 – 2/27 (7%) Lenke type 3 – 8/27 (30%)	83.56 ± 10.96 (70 – 112)	64 ± 7.63 (46 – 72)	Hypokyphosis – 3/27 (11.2%) Normal Kyphosis – 9/27 (33.3%) Hyperkyphosis – 15/27 (55.5%)
					HG	12	16.58 ± 2.63	4:8	58.67 ± 20.56				
4	Sikora-Klak et al. (2021), (22)	Retrospective comparative study	-	82	Screw site	41	15.7 ± 2.0 (13 – 21)	4:37	12 (6 -25)	Lenke type 1 – 39/41 (95.1%) Lenke type 2 – 2/41 (4.9%)	-	-	-
					Band site	41	15.2 ± 1.7 (13 – 21)	6:35		Lenke type 1 – 39/41 (95.1%) Lenke type 2 – 2/41 (4.9%)	-	-	-
5	Pesenti et al. (2020), (19)	Retrospective comparative study	January 2011 to July 2015	124	PS	62	14.9 ± 2.4	16:46	26.4	Lenke type 1 – 53/62 (86%) Lenke type 2 – 9/62 (14%)	-	-	-
					SB	62	15.0 ± 1.9	3:59		Lenke type 1 – 56/62 (91%) Lenke type 2 – 6/62 (9%)	-	-	-

PSG: *Pedicle Screw Group,* ***HG:*** *Hybrid Fixation with Sublaminar band group,* ***AS:*** *All screws,* ***SB:*** *Screw- Sublaminar bands group, Thoracic Hypokyphosis (Cobb angle < 25°), Normal Kyphosis (Cobb angle 25 – 45°), Thoracic Hyperkyphosis (Cobb angle >45°).*

Table II: Peroperative Data

Author	Study Group	n	Operative Time (in minutes)	Intra op Blood Loss (in ml)	No of Vertebrae fused	Upper Instrumented Vertebra (UIV)	Lower Instrumented Vertebra (LIV)	Density of Instruments	Rod materials	Hospital stay (in days)	Proximal Junctional Kyphosis (PJK) at 2 years follow up (in %)	Distal Junctional Kyphosis (DJK) at 2 years follow up (in %)	Thoracic Cobb correction (in %)	Complications
La Maida et al. (2018), (13)	AS	36	246	1098	-	-	-	-	-	-	-	-	-	Deep Infection (n = 2)
	SB	45	208	910	-	-	-	-	-	-	-	-	-	-
Palmisani et al. (2018), (18)	AS	18	180 ± 26	630 ± 150	11.5	-	-	-	-	-	-	-	-	-
	SB	19	200 ± 20	700 ± 160	12.3	-	-	-	-	-	-	-	-	-
Cinella et al. (2019), (4)	PSG	15	386 ± 55.95	-	11.10 ± 1.69	T1 = 2/15 (13.34 %) T2 = 1/15 (6.67%) T3 = 2/15 (13.34%) T4 = 4/15 (26.67%) T5 = 5/15 (33.34%) T6 = 1/15 (6.67%)	T12 = 3/15 (20%) L1 = 4/15 (26.67%) L2 = 2/15 (13.34%) L3 = 0 L4 = 5/15 (33.34%) L5 = 1/15 (6.67%)	1.51 ± 0.10	-	-	-	-	-	Deep Infection (n = 1)
	HG	12	405 ± 49.07	-	11.25 ± 1.83	T1 = 0 T2 = 1/12 (8.34%) T3 = 3/12 (25%) T4 = 7/12 (58.34%) T5 = 1/12 (8.34%) T6 = 0	T12 = 3/12 (25%) L1 = 1/12 (8.34%) L2 = 2/12 (16.67%) L3 = 3/12 (25%) L4 = 3/12 (25%) L5 = 0	1.64 ± 0.12	-	-	-	-	-	Temporary loss of somatic and motor potentials intra opearatively (n = 1)
Sikora Klak et al. (2021), (22)	Screw site	41	-	-	-	T1 – 0 T2 – 5/41 (12.2%) T3 – 23/41 (56.1%) T4 – 13/41 (31.7%)	T11 – 1/41 (2.4%) T12 – 13/41 (31.7%) L1 – 11/41 (26.8%) L2 – 9/41 (22%) L3 – 6/41 (14.6%) L4 – 1/41 (2.4%)	-	Cobalt Chromium – 3 (7.3%) Stainless Steel – 38 (92.7%)	-	-	-	76 ± 12	-
	Band site	41	-	-	-	T1 – 3/41 (7.3%) T2 – 19/41 (46.3%) T3 – 19/41 (46.3%) T4 - 0	T11 – 0 T12 – 0 L1 – 0 L2 – 16/41 (39%) L3 – 24/41 (58.5%) L4 – 1/41 (2.4%)	-	Cobalt Chromium – 41(100%) Stainless Steel - 0	-	-	-	61 ± 14	-
Pesenti et al. (2020), (19)	PS	62	298 ± 67	693 ± 389	11.7 ± 1.4	-	-	-	-	5.3 ± 2.2	13	5	-	-
	SB	62	262 ± 32	381 ± 218	12.1 ± 1.2	-	-	-	-	7.5 ± 1.2	7	1	-	-

Table III: Details of Deformity

Authors	Study groups	Primary Curve (in°)			Secondary Curve (in°)			Cervical Lordosis (C2 – C7) (in°)			Thoracic Kyphosis (T4 – T12) (in°)			T1 tilt (in°)			Lumbar lordosis (L1 – L5) (in°)			Pelvic Tilt (in°)			Pelvic Incidence (in°)			Sagittal imbalance (in mm)			Coronal imbalance (in mm)		
		T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU	T0	T1	FU
La Maida et al. (2018), (13)	AS (n=36)	61.0 (52.7 – 64.5)	18.0 (15.9 – 22.6)	-	55.0 (48.6 – 63.2)	18.4 (15.9 – 21.4)	-	-0.5 (-3.6 – 9.0)	4.0 (-8.3 – 9.3)	-	26.5 (22.3 – 31.4)	23.0 (19.0 – 29.0)	-	8.5 (5.3 – 14.0)	8.5 (5.3 – 14.0)	-	-54.5 (-50.9 – 59.0)	-	-	9.5 (6.0 – 15.0)	12.0 (10.3 – 15.7)	-	48.2 ± 14.1	-	-	-	-	-	-	-	-
	SB (n=45)	61.0 (54.3 – 68.7)	24.0 (20.0 – 28.7)	-	58.0 (50.0 – 61.0)	16.0 (10.9 – 20.0)	-	3.0 (-1.5 – 7.0)	4.0 (1.0 – 7.0)	-	27.0 (19.0 – 32.4)	24.0 (22.0 – 28.2)	-	13.0 (9.0 – 18.0)	11.0 (8.5 – 15.5)	-	-54 (-51.0 – 58.4)	-49 (-46.0 – 53.0)	-	10.0 (8.5 – 12.0)	11.0 (9.0 – 14.0)	-	-	-	-	-	-	-	-	-	-
Palmisani et al. (2018), (18)	AS (n=18)	57 (45 – 96)	18 (6 – 36)	19 (6 – 38)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SB (n=19)	54 (42 – 65)	19 (6 – 38)	21 (10 – 27)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cinella et al. (2019), (4)	PSG (n=15)	80.10 ± 5.51	31.40 ± 7.26	33.40 ± 7.64	48.13 ± 14.58	20.47 ± 11.05	21.87 ± 12.78	-	-	-	41.26 ± 12.46	36.53 ± 4.83	37.27 ± 3.32	-	-	-	52.93 ± 11.26	47.40 ± 9.15	47.60 ± 8.75	-	-	-	-	-	-	-12.78 ± 12.68	-29.21 ± 21.18	-20.07 ± 17.08	22.48 ± 10.14	23.26 ± 17.41	14.44 ± 10.44
	HG (n=12)	87.92 ± 14.06	48 ± 15.09	17.88 ± 12.93	37.42 ± 6.22	21.08 ± 6.85	11.64 ± 5.62	-	-	-	-	-	-	-	-	-	56.16 ± 10.37	50.75 ± 7.61	47.08 ± 7.72	-	-	-	-	-	-	-5 ± 28.66	-13.73 ± 29.56	-13.09 ± 27.28	40.25 ± 6.53	21.83 ± 7.31	11.54 ± 4.57
Sikora Klak et al. (2021), (22)	Screw site (n=41)	-	-	-	-	-	-	-	-	-	22 ± 14	29 ± 5		-	-	-	57 ± 11	60 ± 10		-	-	-	-	-	-	-	-	-	-	-	-
	Band site (n=41)	-	-	-	-	-	-	-	-	-	19 ± 13	23 ± 9		-	-	-	56 ± 8	56 ± 8		-	-	-	-	-	-	-	-	-	-	-	-
Pesenti et al. (2020), (19)	PS (n=62)	55.2 ± 10.1	15.0 ± 7.3	16.0 ± 7.8	36.1 ± 8.0	15.0 ± 8.9	14.4 ± 9.1	5.7 ± 5.4	- 6.2 ± 13.8	- 5.9 ± 15.0	23.9 ± 13.6	18.7 ± 8.4	21.8 ± 10.3	-	-	-	55.2 ± 11.4	47.0 ± 11.2	55.9 ± 12.1	9.8 ± 7.5	12.6 ± 8.6	9.9 ± 8.4	51.0 ± 11.6	-	-	-12.8 ± 36.9	5.8 ± 44.0	-21 ± 30	18.8 ± 13.8	16.6 ± 12.5	11.4 ± 9.8
	SB (n=62)	55.9 ± 11.0	19.1 ± 7.9	22.6 ± 7.8	35.6 ± 6.7	15.4 ± 9.0	16.9 ± 10.3	5.1 ± 12.4	0.3 ± 11.3	2.9 ± 12.3	23.7 ± 12.3	27.5 ± 8.5	34.0 ± 9.7	-	-	-	53.7 ± 11.9	50.4 ± 10.6	59.3 ± 13.3	6.3 ± 6.5	9.0 ± 19.2	5.4 ± 7.6	53.7 ± 11.9	-	-	11.8 ± 20.0	9.4 ± 19.2	-5.4 ± 21.9	14.4 ± 8.9	12.9 ± 10.3	8.7 ± 6.5

***T0:** Preoperative, **T1:** Immediate post-operative, **FU:** Final Follow up.*

Demographic Data

The review included a total of 351 patients across 5 studies with 179 patients in the study group and 172 patients in the control group (Table II). The mean age of the study subjects ranged from 12.9 years to 19.2 years. The study population was largely skewed towards female gender across the studies (M: F; 77:274). Most of the patients had Lenke type 1 curve (241/270, 89.26%) (13–16). 21/233 (9.01%) had Lenke type 2 curve (14-16) and 8/27 (30%) had Lenke type 3 curves (4). One of the studies reported a mean primary scoliotic curve of 83.56° ± 10.96°and mean global flexibility index of 64° ± 7.63° (4). All the included studies except one had a follow up of more than 2 years (22). 20/64 (31.25%) patients had hypokyphosis (thoracic Cobb angle < 25°), 19/64 (29.69%) had hyperkyphosis (thoracic Cobb angle > 45°) and 25/64 (39.06%) had normal kyphosis (thoracic Cobb angle between 25°- 45°) (4,18).

Surgical Outcome

There was less blood loss in the HG group (SMD: 0.30, 95%CI: -1.10,1.69) as compared to PS, while the mean operative time (SMD: -0.14, 95%CI: -1.16,0.88) and the average number of vertebrae fused (SMD: -0.27, 95%CI: -0.59,0.06) are lesser for PS (Figure 2). The forest plots for the operative time and the intra operative blood loss had a very high heterogeneity in their pooled effects (I^2 of 99% and 94% respectively) because the data present among the included studies was inconsistent while the I^2 for the pooled data for the number of vertebrae fused was moderately high (60%) as the data presented in the included studies was consistent but imprecise.

There was no statistical difference in the preoperative scoliotic curves among the included studies. The total correction achieved in the primary scoliotic curve (SMD: -1.64, 95% CI: -3.26, -0.03) was statistically significant for PS group. The correction of lumbar lordosis (SMD: -0.24, 95% CI: -0.50,0.02) was more in PS group while better correction was achieved in the secondary scoliotic curve in HG group (SMD: 0.33, 95% CI: -0.44,1.10), although both these results were found not to be statistically significant (Figure 3). The pooled effect for the primary curve at final follow up had a high heterogeneity (I^2 = 94%) due the data being inconsistent.

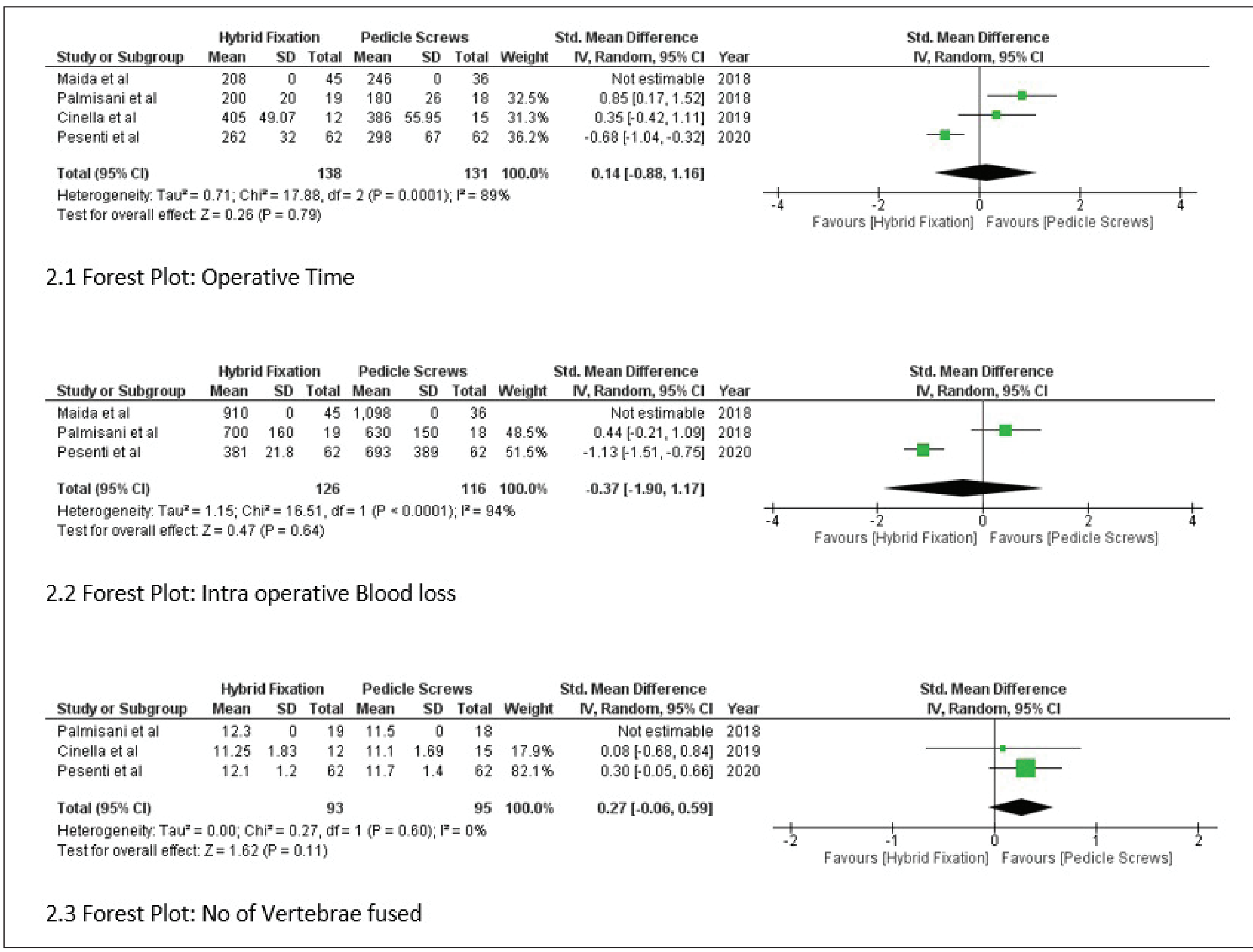

Figure 2: Forest plot on preoperative data.

Meta-analysis of the data for the secondary curves, thoracic curves and the lumbar lordosis in the pre-operative, post-operative and at final follow up had no significant pooled effects (Figure 4,5,6).

Two of the included studies reported the upper and lower instrumented vertebra level in the two fixation methods used (4,22). The most common uppermost instrumented vertebra level reported was T3 for both the groups and the most common lowermost instrumented vertebra level was L1 for PS and L3 for HG (Table II).

Cinella et al. reported the mean density of instrumentation to be 1.51 ± 0.10 for PS and 1.64 ± 0.12 for HG (13). They also gave an account of the functional outcome in the two groups based on the 'Scoliosis research society (SRS - 24)' questionnaire filled up by patients in follow-up visit. The results were comparable with a final post-surgical satisfaction level of 5 ± 0 for both the groups of patients. They reported an average increase in the cervical kyphosis by 4.5° in PS groups while by 1° in HG group. Sikora-Klak et al. reported on the thoracic deformity correction achieved which was 76% ± 12% for PS and 61% ± 14% for HG (22). They reported on the short-term results of deformity correction by the two methods using 3D techniques and their results showed superior corrections for pedicle screw group. They also commented on the rod material used for the surgery was 'stainless steel' in 92.7% patients undergoing PS and 'cobalt -chromium' for the rest 7.3 % patients whereas 'cobalt-chromium' rods were used for 100% patients in HG. Pesenti et al. mentioned the average hospital stay to be 5.3 ± 2.2 days for PS group and 7.5 ± 1.2 days for the HG group (19). They also reported the incidence of proximal junctional kyphosis 2 years after surgery in 13% of the patients in PS and 7% of the patients in HG. Similarly, distal junctional kyphosis 2 years after surgery was reported in 5% patients in PS group and 1% patients in the HG group (Table III). They reported the patients in the PS group had better coronal plane correction with reduction in kyphosis post operatively hence we can infer that the patients with pre-operative hyperkyphosis will have better results with PS. Similarly, patients in HG group had better sagittal plane

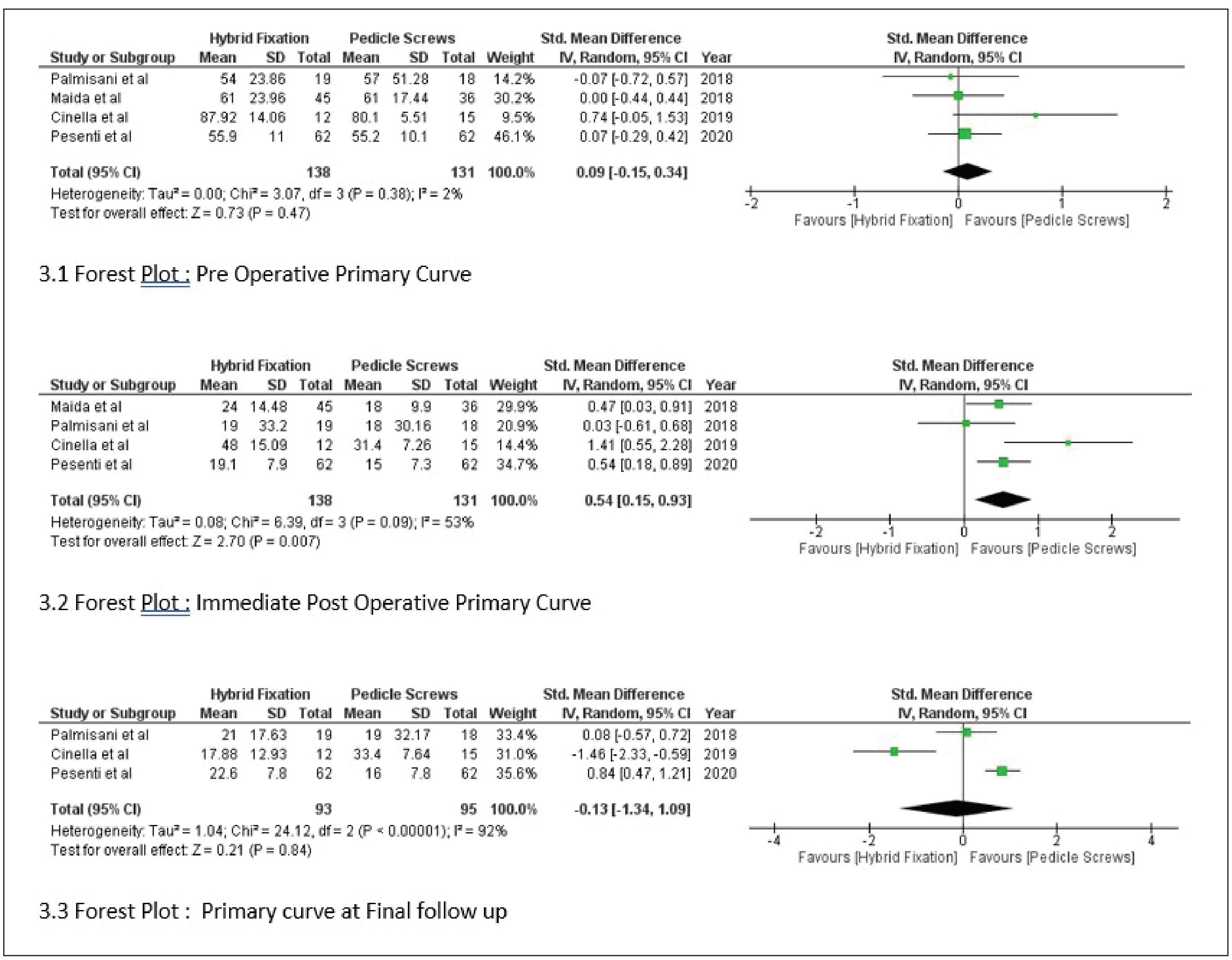

Figure 3: Forest plot on primary curve.

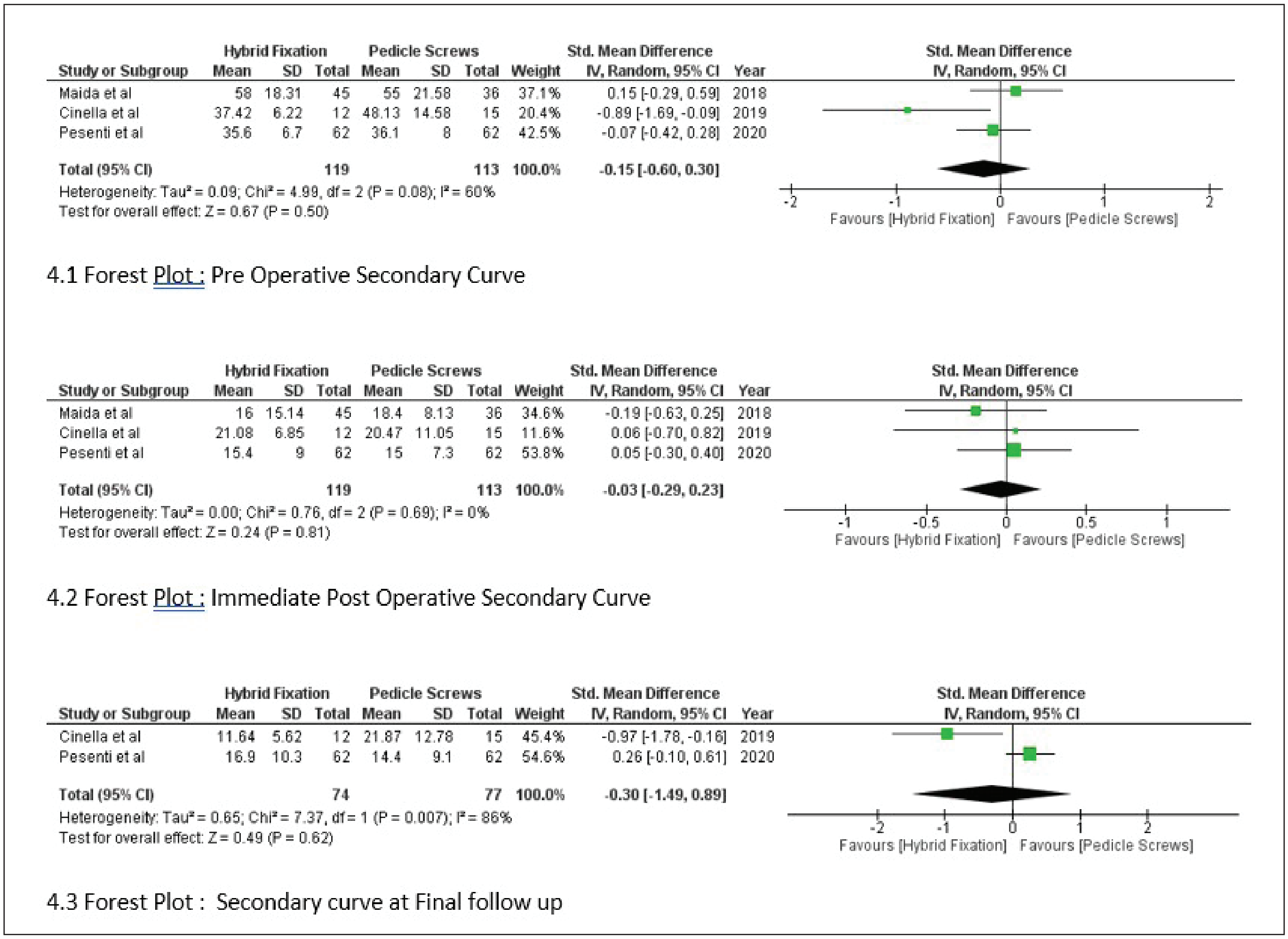

Figure 4: Forest plot on secondary curve.

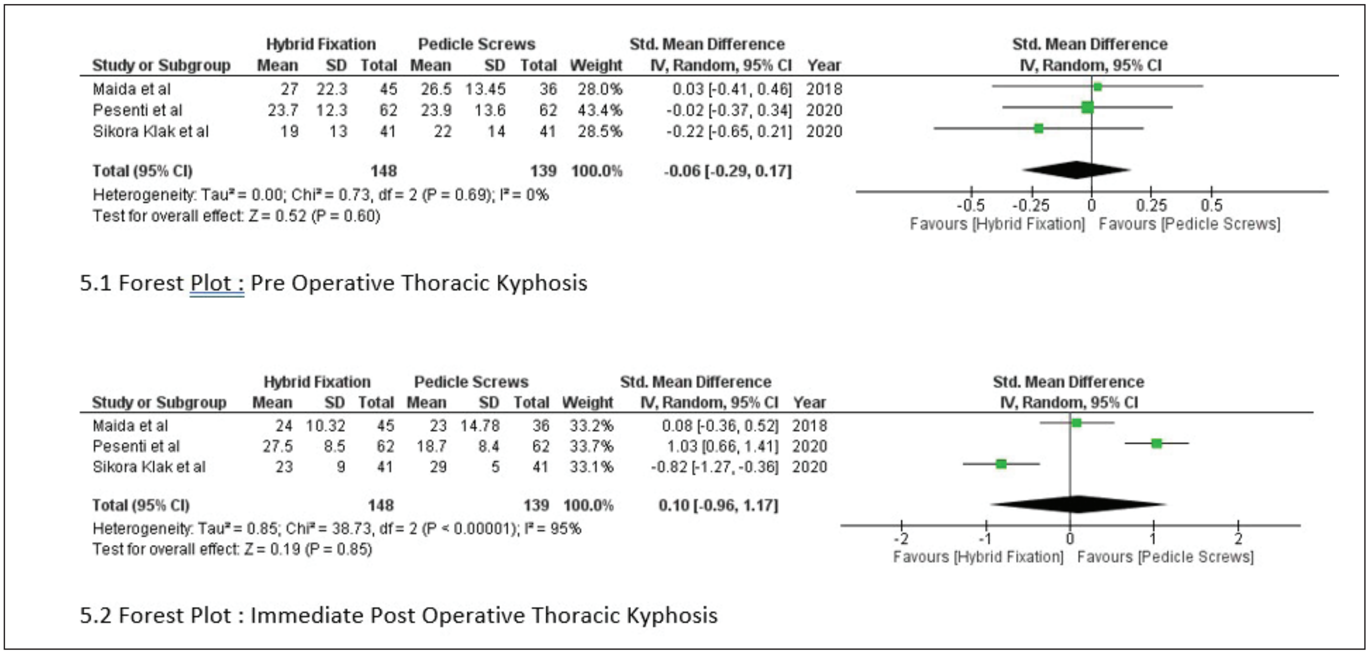

Figure 5: Forest plot on thoracic kyphosis.

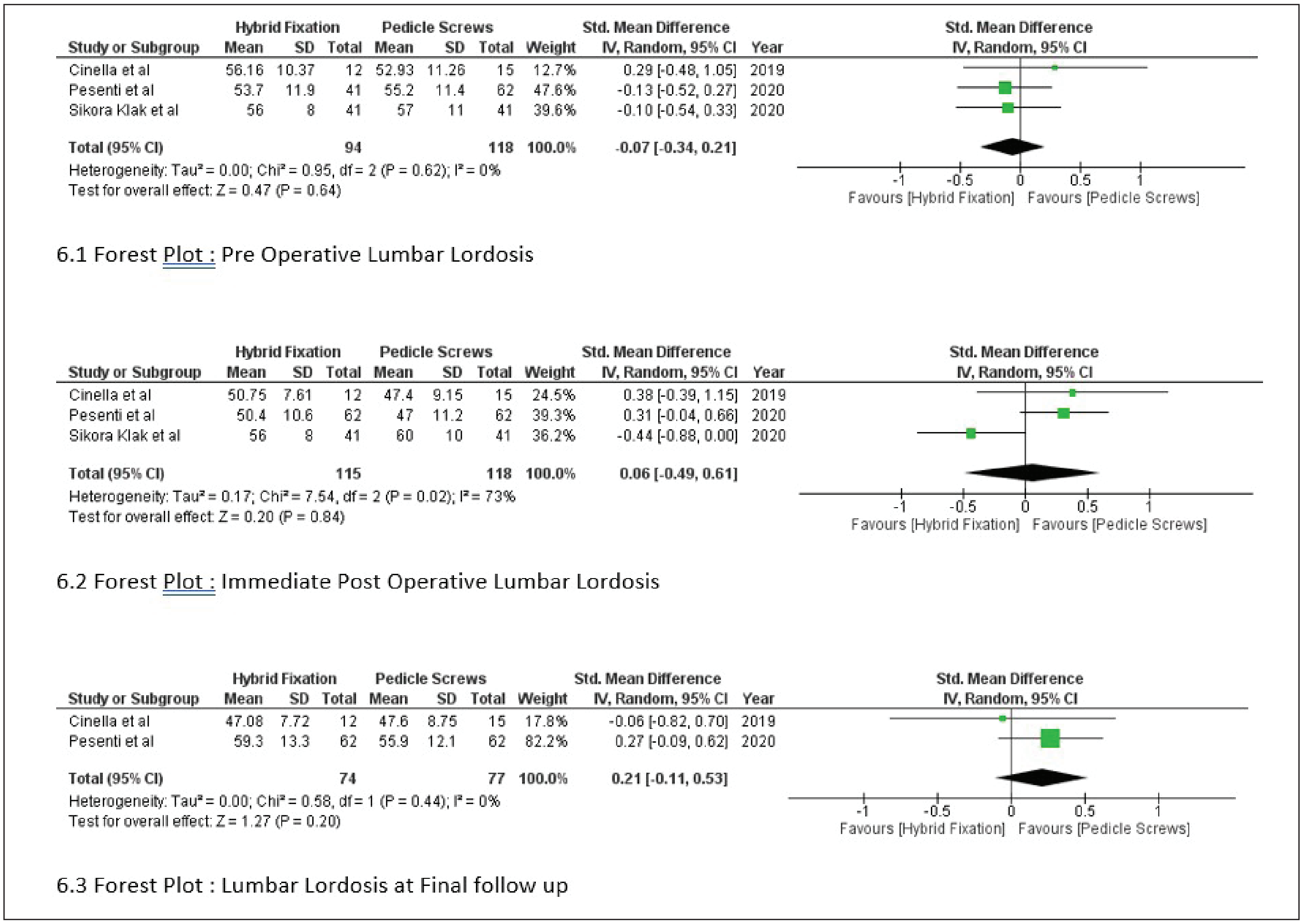

Figure 6: Forest plot on lumbar lordosis.

correction and their kyphosis increased post-operatively so HG is best suited for patients with pre-operative hypokyphosis.

Three of the studies included in the review compared the degree of deformities in the pre operative, post operative and final follow up period in the coronal and sagittal planes while the remaining two studies compared only the corrections achieved in the immediate postoperative period for the respective groups with no details of the follow up (4,13,18,19,22).

Complications

Two of the included studies reported complications in the study subjects (4,13). La Maida et al. reported 2 cases of deep infections in the PS group, one of which required early surgical revision while the other required adding on the previous construct (13). Cinella et al. reported a case of deep infection in the PS group 3 years after surgery which was treated by debridement and implant removal while one patient in the HG group reported a temporary loss of somatic and motor potentials intra operatively which recovered without any intervention (Table III) (4).

DISCUSSION

The goal of surgery in AIS is to obtain a well-balanced stable spine. Posterior instrumentation and spinal fusion are the cornerstone of treatment strategy in AIS. The history of posterior instrumentation begins with the Harrington system where hooks were used to provide distractive forces to correct the curve (7). Posterior instrumentation can be done with various implants like pedicle screws, hooks, claws, sublaminar wires and sublaminar bands. Pedicle screws have been conventionally favoured because the resulting construct is very strong. One can have complications like nerve root injury at the time of pedicle screw insertion and junctional screw pull out. Hybrid constructs using hooks or sublaminar wires and bands along with pedicle screws have been shown to provide improved curve correction (18), having results similar to PS constructs (10,25,30). There have been numerous studies comparing the outcomes of hybrid construct using sublaminar wires or hooks along with pedicle screws against the all pedicle screw construct. The use of sublaminar bands in deformity correction has started recently and the literature on the comparison of its outcomes with that of all pedicle screw constructs is scarce. This review compares the outcomes of posterior approach surgery in AIS using all pedicle screws system (PS) with that of hybrid fixation (HG) method using sublaminar elastic bands along with pedicle screws and demonstrate how effective the above said HG system is against the conventional PS system.

The concept of insertion of screws in the vertebrae was introduced by King (11). The pedicle screw plate construct was described by Roy-Camille et al. in 1970s (20), which formed the basic design on which modern pedicle screws were developed. The use of pedicle screws along with rods for interpeduncular fixation for deformity correction was first introduced by Luque in 1986 (15). All pedicle screws construct has been shown to have higher stiffness and strength as compared to any hybrid construct (13). The PS lead to 'flat back' as the post operative kyphosis decreased drastically (24). Although it gives better curve correction in both coronal and sagittal planes, PS constructs are associated with increased risk of proximal junctional kyphosis, neurological and vascular complications (2,9,22). Aorta is located postero-laterally in right thoracic curves and there is risk of direct injury as well as pseudoaneurysm formation during the application of left sided screws (9). Similarly, the neurological structures lie in closer to the concave side pedicles which increases the risk of neural injury intra-operatively (13). Conversely, the neurological structures are safer while putting screws on the convex side. This has led surgeons to place pedicle screws on the convex side and use hooks or sublaminar wires/bands on the concave side leading to development of a hybrid construct (6).

Although all PS constructs are unequivocally better in correction of coronal curves, the evidence regarding its efficacy in the sagittal curve is conflicting. The effect of PS or HG system on the kyphosis depends on the preoperative level. PS is seen to provide better results in patients with preoperative hyperkyphosis whereas HG is seen to provide better results in patients having preoperative hypokyphosis (19). This difference in the amount of postoperative kyphosis can be attributed to the reduction technique used intraoperatively. Cantilever technique is used to reduce the curves in PS which tends to flatten the kyphosis whereas as posteromedial translation technique is used in HG which pulls the vertebrae posteriorly leading to increased kyphosis post-operatively (26,28). Secondly, greater release of ligamentum flavum is needed to pass the sublaminar band which also contributes to the increased kyphosis in HG group (19). The average number of instrumented levels are slightly higher for HG group. The UIV was at T2 for 10.71% patients and at T3 for 48.21% in the PS group while it was at T2 for 37.73% and T3 for 41.5% patients in HG group. The LIV was at L3 for 58.5% patients in HG group while it was at L1 for 36.8% and L2 for 22% patients in the PS group. The results regarding lower instrumented vertebrae are conflicting (22). The inclusion of L4 or L5 or S1 has been shown to have worse functional scores (21). Longer constructs are associated with increased hospital stay, increased blood loss and increased risk of revision surgery (1,31). Lastly, even though the strength of HG is same as the PS constructs, the higher implant density in HG would lead to interference due to artifacts on MRI if it is needed postoperatively due to any complication (18).

A statistically significant correction of the primary curve is seen in the PS group (Figure 3) while no statistically significant difference in the secondary curves, thoracic curves, lumbar lordosis, mean operative time average blood loss and average number of vertebrae fused was seen between the two groups. The PS appears to be superior to the HG I the immediate post operative period. Both the groups have comparable complication rates. The commonest UIV was T3 in both the groups while the most common LIV was L1 for PS group and L3 for HG group.

Strengths

This study is the first to compare the results of use of PS and HG in AIS. Only comparative studies were considered for this review. An extensive literature search across various databases was done by two authors independently. All the necessary and essential data like curve correction, operative time, blood loss and complication could be assessed across the studies which enabled a meta-analysis were extracted from the eligible studies.

Limitations

This review and meta-analysis has many limitations. We could find only 5 studies fulfilling the inclusion and exclusion criteria. None of the studies is randomised due to which the results of the meta-analysis should be interpreted with caution. Four of the studies were retrospective in nature. Only English language studies were considered hence potentially important studies in other languages may have been excluded from the review. There was low to moderate heterogeneity across all the studies. This could be attributed to factors like type of curve, age at surgery, level of instrumentation and the follow up period. The results are based only a few non randomised retrospective studies hence are to be interpreted with caution.

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CONCLUSION

Although the operative time and the blood loss is less for HG group, it is statistically insignificant. The number of levels fused is less, and better secondary curve correction in HG group. A statistically significant improvement of the main curve was noticed in the PS group. Considering the results, PS constructs can be considered superior to HG constructs using pedicle screws and sublaminar elastic bands.

There is reduced incidence of distal junctional kyphosis and complications in HG. They have better deformity correction in sagittal planes as compared to PS group and is more effective in restoring the kyphosis post-operatively.

We would like to add that the effects of type of instrumentation on the post operative kyphosis achieved and its impact on the quality of life needs to be studied additionally in detail in future studies. A prospective, large scale and multi centric randomized study with a long follow up would provide more robust data on the effect of type of instrumentation on the natural course of AIS after surgery.

Declarations

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AUTHORSHIP CONTRIBUTION

Study conception and design: VK, AJV

Data collection: SB, VR, RR

Analysis and interpretation of results: SB, VR, RR

Draft manuscript preparation: SB, VR, RR

Critical revision of the article: VK, VR

Other (study supervision, fundings, materials, etc...): VK, AJV

All authors (VK, AJV, VR, SB, RR) reviewed the results and approved the final version of the manuscript.

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