# Body Surface Topography and Radiology in Adolescent Idiopathic Scoliosis (AIS): Is there a Correlation? : A Pilot Study Based on Clinical Photographs

**Shiju Majeed[a], Vinod Kumar BP[b], Lubna Adbul Salam[c], Ajina Nahas[c]**

a. Department of Orthopedic Surgery, Government Medical College, Thiruvananthapuram;
b. Department of Orthopedic Surgery, Government Medical College, Alappuzha;
c. Research Associate, Orcigenix Life Sciences,Thiruvananthapuram*

*Published on 21st October 2024*

## ABSTRACT

**Background:** Cosmesis is of paramount importance in adolescent idiopathic scoliosis. Conventional evaluation of scoliotic deformity is based on radiological parameters like Cobbs angle. However aesthetic parameters are the ones that are readily perceived by the patients, peers and parents. Patient Reported Outcome measures and self-image perception of these patients may not be dependent on radiological parameters alone. So there is a need to know whether there is a correlation between body surface topography and radiology in these patients.

**Material and Methods:** Cross-sectional, pilot study of 15 patients (10 thoracolumbar/lumbar and 5 thoracic curves. Clinical evaluation was done via Spinal Appearance Questionnaire, SRS 22 r questionnaire. Surgeon evaluation is done via the POTSI app and TRACES index. Body Surface Metrics were also calculated. Radiological parameters studied were Cobbs angle, apex deviation, Clavicle angle, Coracoid angle First Rib angle, T1 tilt and C7 Plumbline deviation.

**Results**

- POTSI had a strong correlation between SAQ (r value 0.735, p value 0.002).
- SAQ has a moderate correlation with cobbs angle of main curve (r value 0.519 p,0.047) and secondary curve (r value 0.539 p 0.038)
- SAQ had a moderate inverse correlation with SRS22r (r value-0.560, p =0.030).
- LWA-RWA has a moderate inverse correlation with Main Cobbs angle (0.551 p 0.033). WHA has a moderate correlation with Cobbs angle of main curve (0.545, p=0.036)
- However there was also a moderate correlation between apex deviation of the lumbosacral fractional curve with the WHA (0.567, p value 0.035).
- AHA has a moderate correlation between clavicle angle (0.523, p value 0.046) and mild correlation with FRA (0.390) and coracoid angle (0.393)

SHA had no significant correlation between any of the parameters studied.

**Conclusion:** Trunk aesthetic parameters should be given due importance in assessing children with Adolescent idiopathic Scoliosis. They have only moderate correlation with Cobbs angle. However, patients and surgeons perception of deformity has strong correlation. Studies on larger cohorts will be useful to validate the findings of the present study. Shoulder balance continues to be an enigma that requires further studies

**Keywords:** Surface Topography, Adolescent Idiopathic Scoliosis, POTSI, TRACES, SAQ, Shoulder Balance

*See End Note for complete author details

## BACKGROUND AND RATIONALE

Scoliosis is defined as a lateral curvature of the spine more than 10 degrees.[1] (Scoliosis Research Society SRS definition). Though there are various etiologies of scoliosis, those that occur during the adolescent growth spurt are by far the most common. Scoliosis is a three-dimensional deformity with deformity occurring in coronal, transverse and sagittal plane. Traditionally, the measurement of AIS is quantified

*Cite this article as:* Majeed S, Bp VK, Salam LA, Nahas A. Body Surface Topography and Radiology in Adolescent Idiopathic Scoliosis (AIS): Is there a Correlation? : A Pilot Study Based on Clinical Photographs. Kerala Medical Journal. 2024 Oct 17;17(3):144–51.
| DOI: https://doi.org/10.52314/kmj.2024.v17i3.663

**Corresponding Author:**
**Dr. Shiju Majeed, Professor, Department of Orthopedic Surgery, Government Medical College, Thiruvananthapuram.**
**E-mail: shijuhyatt@gmail.com**

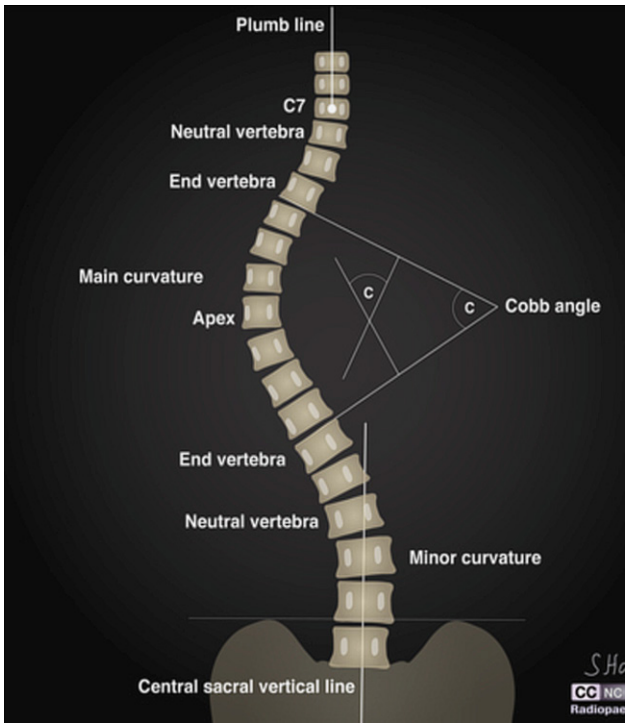



Figure 1. **Demonstrates the method of measurement of Cobbs angle**

using a radiological parameter known as Cobb's angle **(Figure 1)**.

However, Cobbs angle measures only one component of the 3D deformity. It is only a shadow of the two limit vertebra according to Kotwicki.[2]

However Cobbs angle has a dogmatic halo in measuring the degree of scoliosis and also assessing progression as most orthopedic surgeons are familiar with this measurement.

However, patients with AIS are quite concerned about their cosmesis and Cobb's measurement seems only to be a surrogate measure of their own physical assessment. Authors have noticed that the following features are very important for a patient in their own assessment of their body shape. They are symmetry of shoulders, symmetry of axillary folds, symmetry of waist folds, scapular prominence, pelvic symmetry, limb length equality and neck tilt. This applies well to parents perspective of their childs body shape as well.

The cosmetic improvement of the trunk after any treatment for scoliosis is the pinnacle that any child undergoing such treatments will expect. The symmetry of the trunk is what is seen and applauded by the patients, parents and peers. Sometimes, the surgeon is faced with the blooper situation where a good radiological outcome may not guarantee the same cosmetic outcome. Obviously, this would mean that other radiological parameters have an interplay in achieving a satisfactory cosmetic outcome.

The goal of any surgical correction for scoliosis is three fold 1. to prevent worsening and to correct the deformity as much as possible

- with minimal morbidities (Safety)

- to fuse shortest possible
  - preserving maximum mobility (Function)
- to achieved a well balanced and less deformed spine (Cosmetic).

In recent years, many authors from Asia[3-5] have emphasised on the need for achieving spinal balancing rather than a pure radiological correction. A balanced spine would mean a symmetric shoulder, axillary fold , waist and pelvis. Many of us have also observed that often two equal and opposite curves cancel out each other and achieves a certain symmetry – traditionally called as compensated deformity.

Various Spinal topographic measures[6] are in vogue. However, all of them are limited in their clinical use by inter and intraobserver errors due to the fact that landmarks used for measurement suffer from lack of concurrence. However, these are the only quantifiable markers of aesthesis and it would be prudent to know whether there exists a correlation between these aesthetic parameters and radiological parameters. One also need to assess the cosmesis from patients perspective and Patient Reported Outcomes. (Spinal Appearance Questionnaire[7] and SRS 22r.[8] Also of importance is Surgeons perspective in the assessment of cosmesis (TRACE[9] and POTSI[10]). A good correlation between patient and surgeons perspective will guarantee satisfaction for both parties at the end of long and arduous course of treatment.

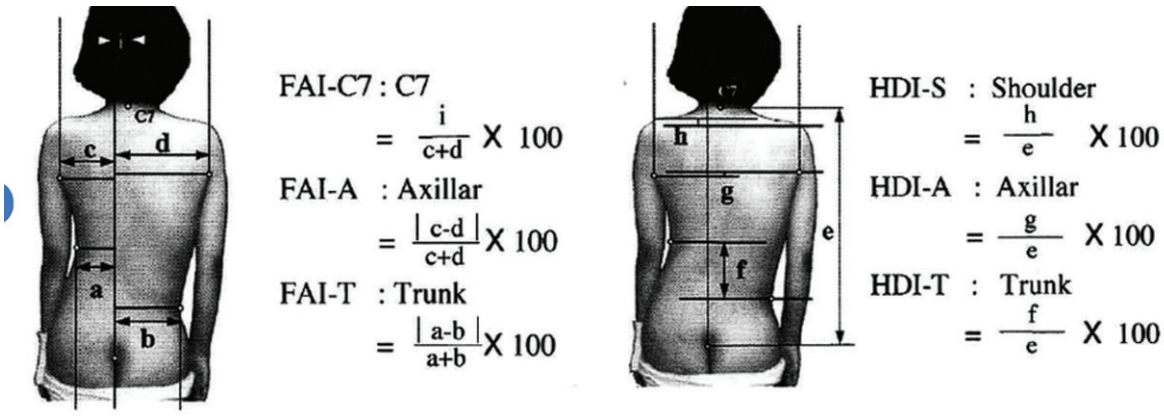
Hence we conducted a pilot study to look at their correlation.

## MATERIALS AND METHODS

**Study design:** Cross sectional , Pilot Study.

**Inclusion criteria:** Patients with adolescent idiopathic scoliosis between 10 to 20 years. Non idiopathic causes were excluded.

15 patients with AIS who visited the Outpatient at Department of Orthopedics, GMC, Thiruvananthapuram were chosen. All patients were photographed from the back as per standard protocol. All patients filled the Appearance part of SAQ, SRS 22 r,. TRACES was calculated by two investigators who were adequatedly trained, FAI, HAI and POTSI index was calculated using software POTSI app using digital photographs. Standard technique of taking Xrays were followed and following




POsterior Trunk Symmetry Index (POTSI) after [56,61]. The POsterior Trunk Symmetry Index (POTSI) is computed as a sum of the 6 indices: POTSI = (FAI-C7 + FAI-A + FAI-T) + (HDI-S + HDI-A + HDI-T).

Figure 2. **Showing how POTSI index is calculated**

radiological parameters were recorded—cobbs angle, apical vertebra translation, clavicle angle, first rib angle, Coracoid angle and C7 plumbline deviation.

### Spinal Appearance Questionnaire: SAQ[7]

The SAQ is a 33-question assessment broken down into different sections. There are 11 pictorial questions the individual identifies what most looks like themselves. This is the Appearance part of the questionnaire. Questions 13 through 32 (expectation part) are rating questions where the individual rates each item out of 5 ratings these include: not true, a little true, somewhat true, Fairly true, or very true. We have considered only the questions relevant to appearance from the back in this study.

SRS 22r[8] is a widely used tool for assessing outcome in AIS. It is a PROM.

The SRS-22r contains 22 questions in five domains:

- function (5 items),
- pain (5 items),
- self-image (5 items),
- mental health (5 items),
- satisfaction with management (2 items). Each item contains a 5-level Likert scale ranging from worst (1 point) to best (5 point); results are expressed as the mean score of each domain, and total score of the scale. The functional domain of SRS 22r questionnaire will be used to assess the change in function

A higher total score indicates a higher level of quality of life. In this study, we have taken into account the self image, mental status and total SRS score.

TRACE[9] is based on four sub-scales: shoulders, scapulae and waist (which were already present in the AI), and the hemi-thorax. Shoulder ranged for 0-3, Waist from 0-4, scapula from 0-2, hemithorax from 0-2 thus forming a maximum total score of 12.

### POTSI Index[10]

The Potsi Index is the sum of two variables Height Asymmetry Index (HAI) and Frontal Asymmetry Index (FAI). Height asymmetry indexes are obtained as the sum of height differences of the shoulders, axillary folds, and waist creases, and it is normalized with the division of its value by the vertical distance from the C7 vertebra to the baseline of the gluteal cleft **(Figure 2).**

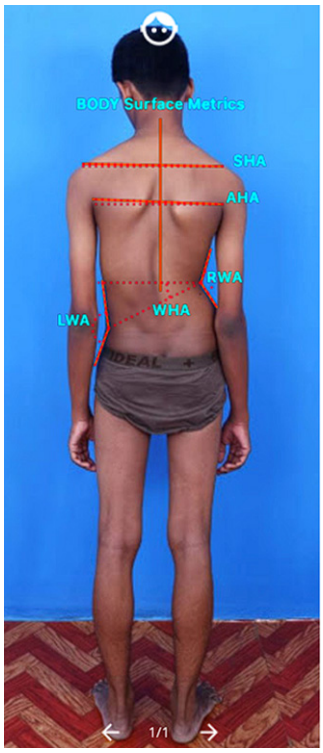



Figure 3. **Points taken to calculate the Body Surface Metrics**

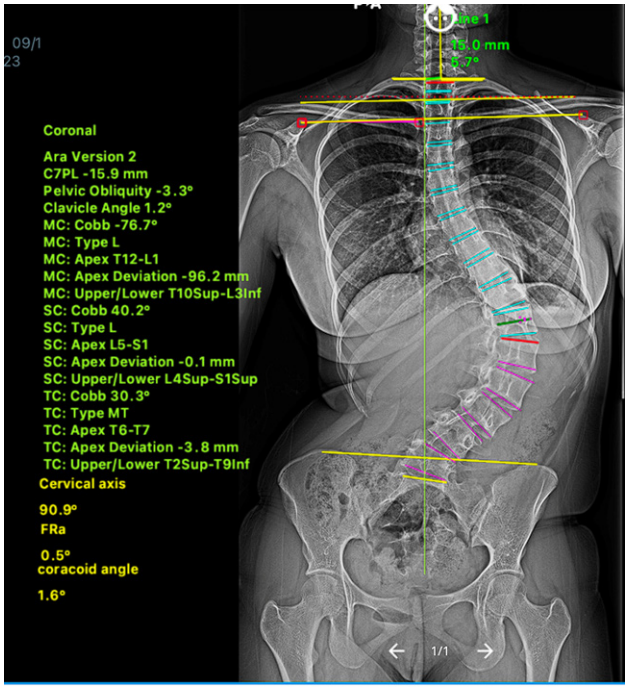



Figure 4. **Calculation of various radiological parameters**

The POTSI index will be calculated by the POTSI app from the clinical photographs of the patient.

Body Surface metrix is calculated from a digital photograph from the back. The following measures are taken LWA, RWA, WHA, AHA, SHA **(Figure 3).**

### Radiological outcome

Is assessed by full length erect radiographs of spine with posteroanterior views and lateral views.

### Xray protocol

- Whole spine Scanogram extended from (but not limited to) bilateral External Auditory Meatus to bilateral femoral heads. Anteroposterior and lateral.
- The patient will be positioned at a distance of 72 inches from the X-ray tube with the central ray targeting at the T6–T7 area.
- X-Rays will be taken with patient in standing position with neck neutral flexed and both the arms in 90* flexion, elbows and wrists flexed such that the fingers touch the ipsilateral shoulders.
- Preoperative radiographs include Supine right side bending and left side bending anteroposterior x-rays to assess curve flexibility.
- No fulcrum x-rays are assessed. The typical radiographic exposure factors were 25 mAs and 100 kVp.
- **Figure 4** showing representative image of how the radiological parameters were calculated.

### How to take Clinical photographs for the study?[11]

Figure 5. **Method to take the clinical photograph**

### Figure 5

- Wears underpants for photo from back
- Stands against a blank wall
- Arm by the sides, hair put-up
- Shot with mobile camera from 2 m centering inter-scapular area

All data will be entered in an excel file. Following correlations were assessed

1. POTSI vs cobbs angle
2. POTSI vs SAQappearance score
3. POTSI vs Srs 22
4. POTSI vs TRACE
5. POTSI VS APEX DEVIATION OF MC,SC,TC
6. SAQ VS COBBS ANGLE
7. SAQ VS APEX DEVIATION
8. SAQ VS SRS22
9. SAQ VS TRACE
10. LWA-RWA VS COBBS
11. WHA vs cobb's, Apex deviation
12. AHA vs cobbs, Apex deviation
13. SHA Vs cobbs , Apex deviation
14. WHA vs Pelvic obliquity
15. SHA vs coracoid angle
16. SHA Vs FRA
17. SHA vs clavicle angle

**Table 1. Descriptive**

| | Mean±SD |
|---|---|
| POTSI | 35.17±13.74 |
| SRS22-Self image | 2.85±0.44 |
| SRS22-Mental health | 3.32±0.66 |
| SRS22-Total | 3.54±0.47 |
| SAQ Appearance score | 2.85±0.61 |
| Trace score | 6.4±1.76 |
| Cobb Angle (º)- MC | 58.19±12.55 |
| Apex Deviation (mm)- MC | 92.77±47.61 |
| Cobb Angle (º)- SC | 34.65±11.47 |
| Apex Deviation (mm)- SC | 17.09±12.27 |
| Cobb Angle (º)- TC | 20.71±6.86 |
| Apex Deviation (mm)- TC | 9.35±11.39 |
| LWA-RWA | 20.85±29.03 |
| WHA (º) | 8.69±6.63 |
| AHA (º) | 3.09±3.3 |
| SHA (º) | 1.67±1.73 |
| Pelvic Obliquity (º) | 3.39±2.16 |
| Corocoid Angle (º) | 1.83±1.62 |
| First Rib Angle (º) | 2.78±3.75 |
| Clavicle angle (º) | 1.85±1.97 |
| T1 TILT (º) | 5.91±7.49 |
| C7PL(mm) | 28.95±12.77 |

**Table 2. Correlation between POTSI and other outcome measures**

| | POTSI r value | 95% Confidence Intervals | | P value |
|---|---|---|---|---|
| | | Lower | Upper | |
| SAQ Appearance score | .735** | 0.358 | 0.906 | 0.002 |
| SRS22-Self image | -0.359 | -0.736 | 0.188 | 0.189 |
| SRS22-Mental health | -0.246 | -0.673 | 0.305 | 0.377 |
| SRS22-Total | -0.425 | -0.770 | 0.112 | 0.114 |
| Trace score | 0.428 | -0.108 | 0.771 | 0.111 |
| Cobb Angle (º)- MC | 0.299 | -0.251 | 0.704 | 0.278 |
| Apex Deviation (mm)- MC | 0.014 | -0.502 | 0.522 | 0.961 |
| Cobb Angle (º)- SC | 0.170 | -0.375 | 0.628 | 0.544 |
| Apex Deviation (mm)- SC | -0.388 | -0.751 | 0.155 | 0.153 |
| Cobb Angle (º)- TC | -0.203 | -0.662 | 0.367 | 0.486 |
| Apex Deviation (mm)- TC | 0.297 | -0.278 | 0.715 | 0.303 |

18. SHA vs T1 tilt
19. AHA vs coracoid angle
20. AHA Vs FRA
21. AHA vs clavicle angle
22. AHA vs T1 tilt

The results are shown below in the following **tables (Tables 1-7).** There were 11 females and 4 males in the cohort. 5 cases were thoracic scoliosis and 10 were thoracolumbar/lumbar scoliosis.

**Table 3. Correlation between SAQ score and other outcome measures**

| | SAQ Appearance score r value | 95% Confidence Intervals | | P value |
|---|---|---|---|---|
| | | Lower | Upper | |
| Cobb Angle (º)- MC | .519* | 0.009 | 0.815 | 0.047 |
| Apex Deviation (mm)- MC | 0.059 | -0.467 | 0.554 | 0.835 |
| Cobb Angle (º)- SC | .539* | 0.037 | 0.824 | 0.038 |
| Apex Deviation (mm)- SC | -0.001 | -0.513 | 0.511 | 0.996 |
| Cobb Angle (º)- TC | -0.096 | -0.596 | 0.458 | 0.745 |
| Apex Deviation (mm)- TC | 0.267 | -0.307 | 0.699 | 0.355 |
| SRS22- Self image | -0.262 | -0.683 | 0.289 | 0.346 |
| SRS22- Mental health | -0.410 | -0.762 | 0.130 | 0.129 |
| SRS22-Total | -.560* | -0.833 | -0.067 | 0.030 |
| Trace score | 0.491 | -0.029 | 0.802 | 0.063 |

**Table 4. Correlation between LWA-RWA and other outcome measures**

| | LWA-RWA r value | 95% Confidence Intervals | | P value |
|---|---|---|---|---|
| | | Lower | Upper | |
| Cobb Angle (º)- MC | .551* | 0.054 | 0.829 | 0.033 |
| Apex Deviation (mm)- MC | -0.155 | -0.618 | 0.388 | 0.581 |
| Cobb Angle (º)- SC | 0.327 | -0.223 | 0.719 | 0.235 |
| Apex Deviation (mm)- SC | -0.344 | -0.728 | 0.204 | 0.209 |
| Cobb Angle (º)- TC | 0.139 | -0.423 | 0.623 | 0.637 |
| Apex Deviation (mm)- TC | -0.215 | -0.669 | 0.356 | 0.461 |

**Table 5. Correlation between WHA and other outcome measures**

| | WHA (º) r value | 95% Confidence Intervals | | P value |
|---|---|---|---|---|
| | | Lower | Upper | |
| Cobb Angle (º)- MC | .545* | 0.045 | 0.826 | 0.036 |
| Apex Deviation (mm)- MC | 0.411 | -0.128 | 0.763 | 0.128 |
| Cobb Angle (º)- SC | .523* | 0.015 | 0.817 | 0.045 |
| Apex Deviation (mm)- SC | -0.068 | -0.561 | 0.461 | 0.811 |
| Cobb Angle (º)- TC | -0.255 | -0.692 | 0.319 | 0.379 |
| Apex Deviation (mm)- TC | .567* | 0.052 | 0.844 | 0.035 |
| Pelvic Obliquity (º) | -0.101 | -0.583 | 0.433 | 0.719 |

**Figures 6 to figures 9** show representative cases and their radiology. (case numbers 11,12,13,14 in the series. For their individual parameters refer Appendix: supplementary material - data for pilot study.

## RESULTS

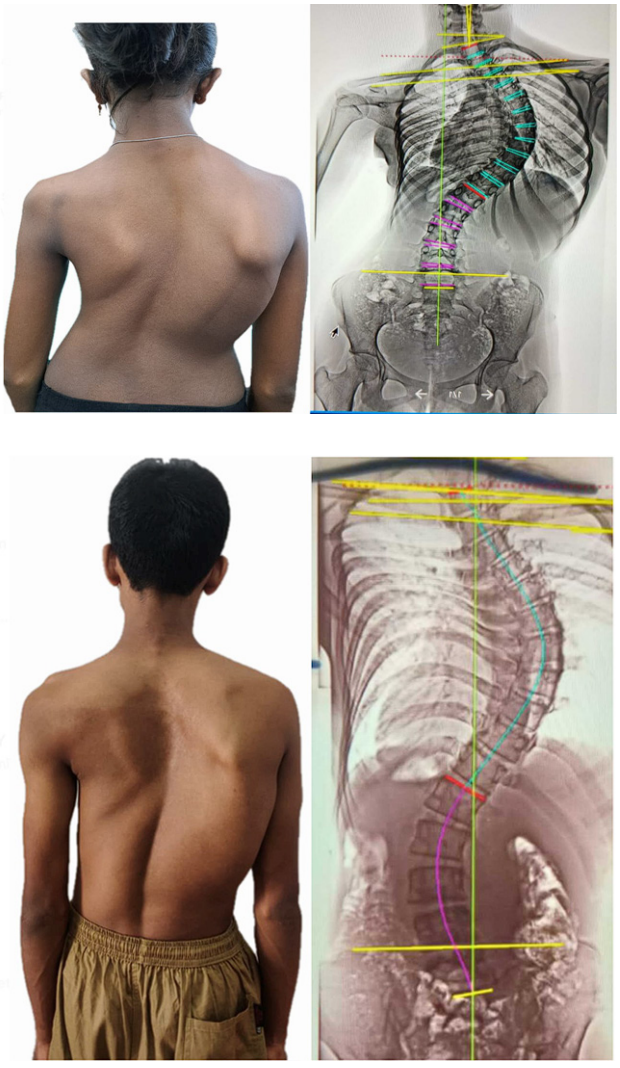
- POTSI had a strong correlation between SAQ (r value 0.735, p value 0.002).
- SAQ has a moderate correlation with cobbs angle of main curve (r value 0.519 p,0.047) and secondary curve (r value 0.539 p 0.038).

**Table 6. Correlation between AHA and other outcome measures**

| | AHA (º) r value | 95% Confidence Intervals | | P value |
|---|---|---|---|---|
| | | Lower | Upper | |
| Cobb Angle (º)- MC | 0.215 | -0.334 | 0.655 | 0.442 |
| Apex Deviation (mm)- MC | -0.170 | -0.628 | 0.375 | 0.545 |
| Cobb Angle (º)- SC | 0.302 | -0.248 | 0.705 | 0.273 |
| Apex Deviation (mm)- SC | -0.254 | -0.678 | 0.296 | 0.360 |
| Cobb Angle (º)- TC | -0.234 | -0.680 | 0.339 | 0.421 |
| Apex Deviation (mm)- TC | 0.068 | -0.480 | 0.578 | 0.818 |
| Corocoid Angle (º) | 0.393 | -0.149 | 0.754 | 0.147 |
| First Rib Angle (º) | 0.390 | -0.153 | 0.752 | 0.151 |
| Clavicle angle (º) | .523* | 0.014 | 0.816 | 0.046 |
| T1 TILT (º) | 0.118 | -0.420 | 0.594 | 0.675 |

**Table 7. Correlation between SHA and other outcome measures**

| | SHA (º) r value | 95% Confidence Intervals | | P value |
|---|---|---|---|---|
| | | Lower | Upper | |
| Cobb Angle (º)- MC | 0.250 | -0.301 | 0.675 | 0.370 |
| Apex Deviation (mm)- MC | 0.065 | -0.463 | 0.559 | 0.818 |
| Cobb Angle (º)- SC | 0.124 | -0.414 | 0.598 | 0.659 |
| Apex Deviation (mm)- SC | -0.191 | -0.641 | 0.356 | 0.495 |
| Cobb Angle (º)- TC | -0.106 | -0.603 | 0.450 | 0.718 |
| Apex Deviation (mm)- TC | 0.142 | -0.420 | 0.625 | 0.628 |
| Corocoid Angle (º) | 0.201 | -0.347 | 0.647 | 0.472 |
| First Rib Angle (º) | 0.382 | -0.162 | 0.748 | 0.160 |
| Clavicle angle (º) | 0.330 | -0.219 | 0.720 | 0.230 |
| T1 TILT (º) | 0.133 | -0.407 | 0.604 | 0.636 |



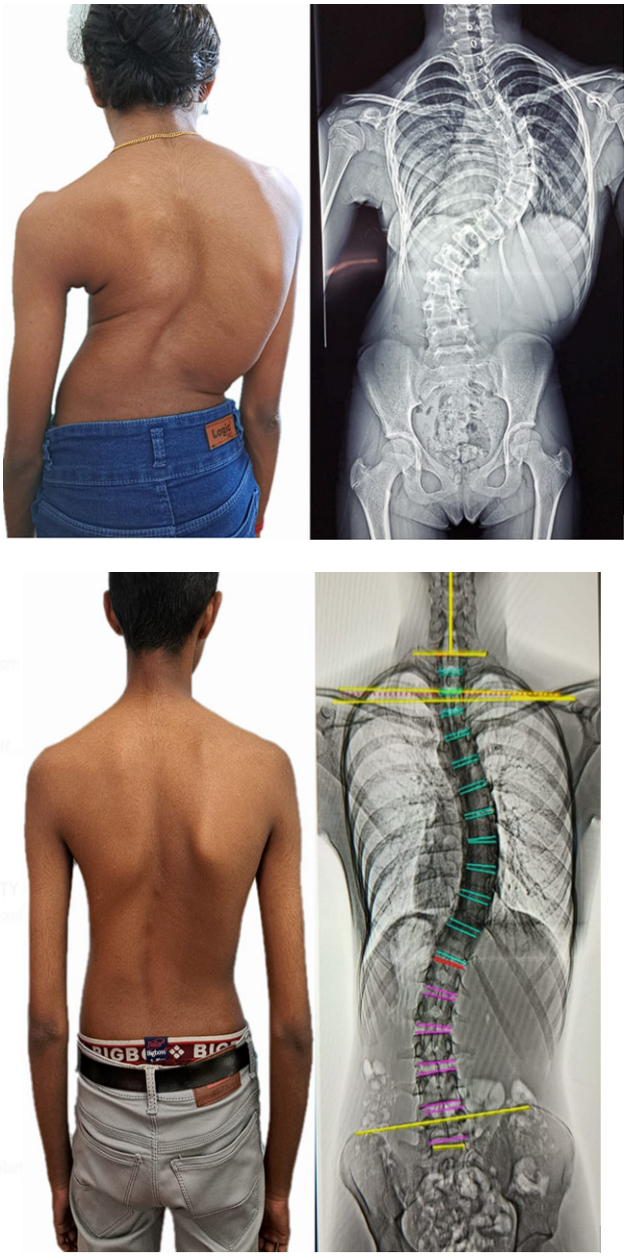


Figure 6-9. **Showing representative clinical photos and their x-rays**

- SAQ had a moderate inverse correlation with SRS22r (r value-0.560, p =0.030).
- LWA-RWA has a moderate inverse correlation with Main Cobbs angle (0.551 p 0.033). WHA has a moderate correlation with Cobbs angle of main curve (0.545, p=0.036)
- However there was also a moderate correlation between apex deviation of the lumbosacral fractional curve with the WHA (0.567, p value 0.035).
- AHA has a moderate correlation between clavicle angle (0.523, p value 0.046) and mild correlation with FRA (0.390) and coracoid angle (0.393)
- SHA had no significant correlation between any of the parameters studied.

## DISCUSSION

Patients with Adolescent Idiopathic Scoliosis seek treatment largely for their body disfigurement. However radiological parameters are given great importance conventionally. However, there are many body topographic parameters that are very important for the patients in their own self assessment of body image. The concept of spinal balancing aims to provide the patient with the best possible aesthetic outcome and not just rely on radiological parameters alone. This pilot study was undertaken to assess the feasibility of a larger study assessing patients aesthesis, function and radiological improvement following corrective surgery for scoliosis. The study will assess many factors like shoulder balance, pelvic symmetry, rib coplanarity, neck tilt etc which are of paramount importance to the patients undergoing surgical correction. The pilot study shows that patients perception of deformity (SAQ) and surgeons perception (POTSI) has a strong correlation. However patients perception of deformity and PROM like SRS 22r has only a moderate correlation with radiological Cobbs angle. This has been emphasised by many authors in the past.[6,2] Extent of correction of Main Curve and its effect on subsidiary curves should be carefully taken into account while planning surgical correction to achieve a good spinal balance. However in lumbar/thoracolumbar curves, the lumbosacral fractional curve is important in achieving a symmetric pelvis and waist. However, surgeon needs to balance between losing of flexibility at the expense of a better cosmetic correction.

Achieving a balanced shoulder is a critical component of any AIS surgery. However, till date there are no specific parameters that can be used intraoperatively with high success rate in achieving this goal. This may be because shoulder is not directly connected to the spine though it is an important component in the perception of deformity. Should balance is contributed by spine, rib cage and shoulder girdle. In this pilot study also, no significant correlation existed between any of the parameters studied and achievement of shoulder balance. However, due to small number of thoracic curves in the pilot study, it is not prudent to make a passing conclusion. Also axillary height has a moderate correlation with clavicle angle. This would imply a role in adaptive changes in shoulder suspensory complex in patients with scoliotic deformities.

## LIMITATIONS OF THE STUDY

Our study is only a pilot study in 15 preoperative patients. We have not included the effect of neck tilt or medial shoulder balance in this study. Our pilot study is also limited by fewer number of thoracic curves in the study population. However, the study gives a rough idea of how the larger study with more number of cases will span out.

## CONCLUSION

Trunk aesthetic parameters should be given due importance in assessing children with Adolescent idiopathic Scoliosis. They have only moderate correlation with Cobbs angle. However , patients and surgeons perception of deformity has strong correlation. Studies on larger cohort will be useful to validate the findings of the present study. Shoulder balance still continues to be an enigma which requires further studies.

## END NOTE

**Author Information**

1. Dr Shiju Majeed, Professor,
   Department of Orthopedic Surgery,
   Government Medical College, Thiruvananthapuram
2. Dr Vinod Kumar BP, Professor,
   Department of Orthopedic Surgery,
   Department of Orthopedic Surgery,
   Government Medical College, Alappuzha
3. Lubna Adbul Salam, Research Associate
4. Ajina Nahas, Research Associate

### List of Abbreviations

| | | | |
|---|---|---|---|
| SAQ | Spinal Appearance Questionnaire | WHA | Waist Height Angle |
| SRS | Scoliosis Research Society | AHA | Axillary Height angle |
| FAI | Frontal Asymmetry Index | SHA | Shoulder Height Angle |
| HAI | Height Asymmetry Index | FRA | First Rib angle |
| POTSI | Posterior Trunk Symmetry Index | MC | Main curve |
| TRACES | Trunk Aesthetic Clinical Evaluation | SC | Secondary Curve |
| LWA | Left Waist Angle | TC | Tertiary Curve |
| RWA | Right Waist Angle | | 600 |

**Acknowledgements:** The authors wish to acknowledge the help given by Dr. Aneesh D and Sivasambath S of Orcigenix Life Sciences in conceptualising the study, Dr Aryadevi for the statistical work.

**Conflict of Interest:** None declared

**Appendix:** Data Chart Pilot study

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