# THE GLOBAL CURVE INDEX (GCI): MY PROPOSAL FOR A NOVEL ASSESSMENT OF IDIOPATHIC SCOLIOSIS

## Critical analysis of traditional assessment methods and introduction of a new parameter for a more comprehensive evaluation of scoliotic deformity

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Throughout my fifty-year professional career dedicated to the study and treatment of spinal deformities, I have observed that assessing the severity of scoliosis is one of the most important, yet also one of the most complex, aspects of the clinical evaluation of affected patients.

The methods traditionally used to guide therapeutic decisions and monitor deformity progression can be summarized as follows:

- radiographic measurement of the curve using standing posteroanterior radiographs and side-bending radiographs, according to the **Cobb** method;
- curve measurement using radiographs obtained in the plane of maximum curvature;
- computed tomography (CT) evaluation;
- magnetic resonance imaging (MRI) assessment;
- clinical evaluation of vertebral rotation through gibbometry.

The most accurate method for representing the true three-dimensional deformity would probably be radiography performed in the plane of maximum curvature, located with fluoroscopic guidance. However, routine use of this technique would involve radiation exposure that cannot be justified for standard follow-up in patients with scoliosis.

**Pierre Stagnara** suggested obtaining this projection by orienting the radiographic beam at 90° to the lateral plane of the rib prominence (Fig. 1).

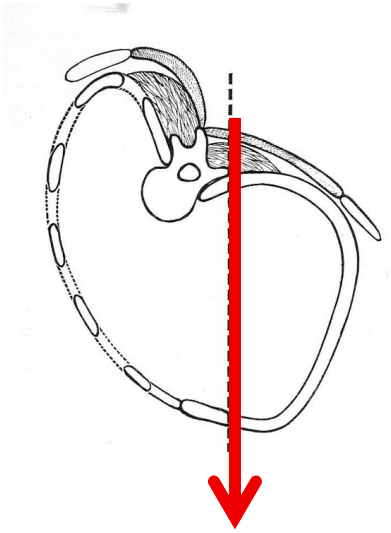


**Figure 1** *Projection for assessment of rib prominence, obtained with the X-ray beam oriented at 90° to the lateral plane of the prominence, according to the method proposed by Pierre Stagnara.*

While acknowledging the historical and scientific value of this approach, my clinical experience has shown that it presents inevitable practical limitations related to the complexity of three-dimensional vertebral deformity and morphological alterations.

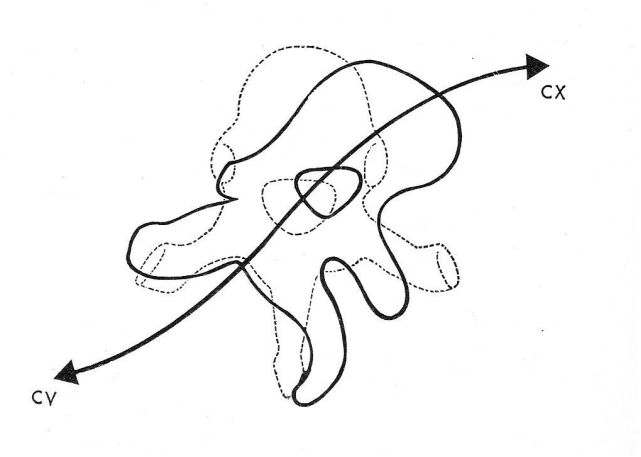



**Figure 2** *Three-dimensional vertebral deformity and morphological alterations associated with idiopathic scoliosis (Gonon 1979)*

Similarly, although MRI avoids exposure to ionizing radiation, it cannot currently be considered a routine examination for scoliosis assessment.

# THE LIMITATIONS OF THE COBB ANGLE AND THE NEED FOR A NEW THREE-DIMENSIONAL ASSESSMENT OF SCOLIOSIS: MY EXPERIENCE

For many decades, prognostic evaluation and therapeutic decision-making in scoliosis have been largely based on the studies of Pierre Stagnara, who identified the Cobb angle as the fundamental parameter for quantifying deformity severity and guiding treatment indications.

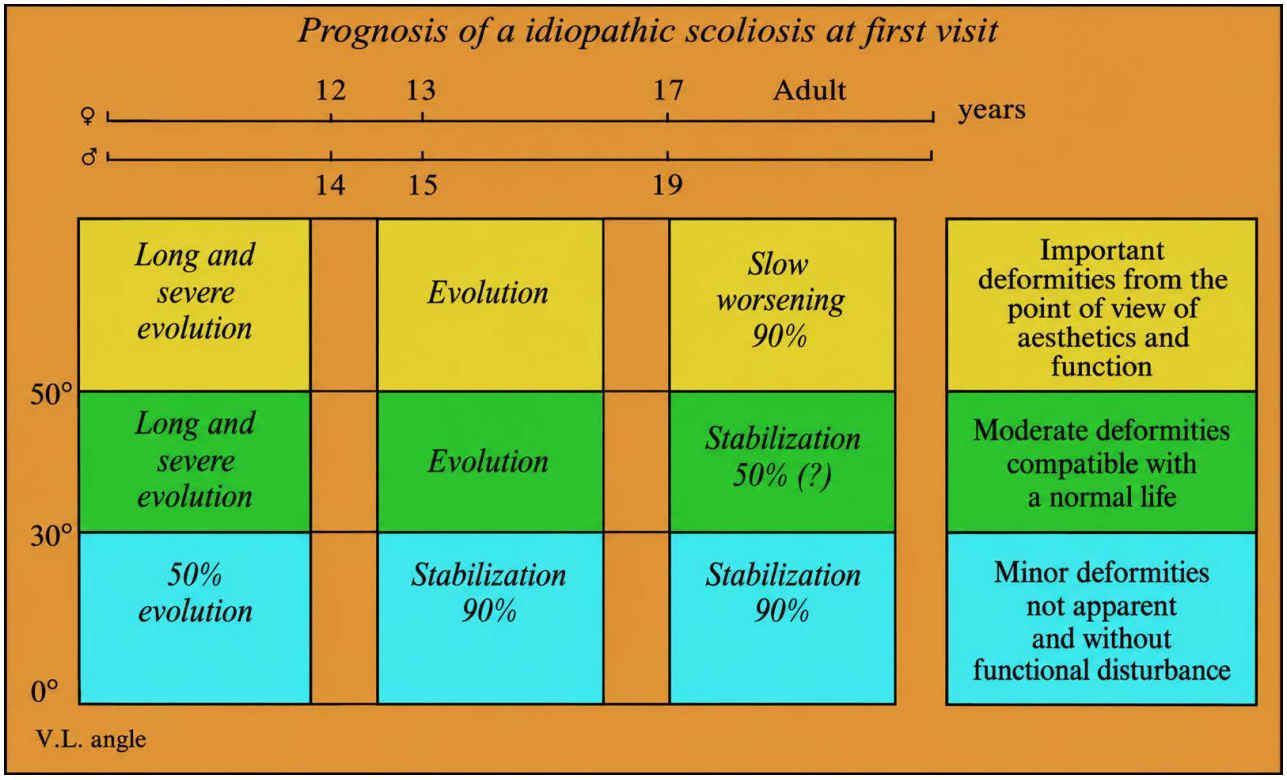
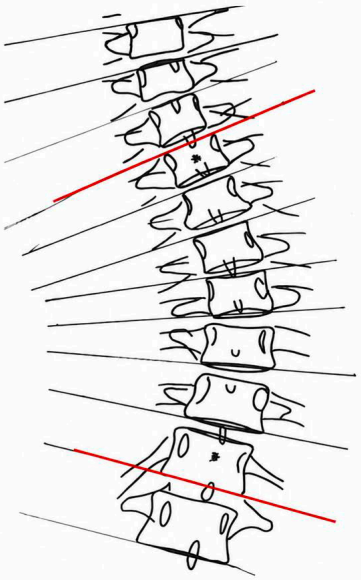



**Figure 3** *Stagnara's prognostic assessment scheme for idiopathic scoliosis at the first clinical evaluation*.

This approach relies on radiographic measurement in the coronal plane, the anatomical plane that divides the body into anterior and posterior portions. In this projection, the lateral deviation of the spine is assessed and the Cobb angle is measured; this remains the most widely used reference parameter in clinical practice.



This method is based on measuring the angle formed by:

- the **superior endplate** of the **upper end vertebra** of the curve
- the **inferior endplate** of the **lower end vertebra** of the curve

The introduction of this method represented a milestone in modern spinal deformity management, as it provided objective, reproducible, and universally accepted diagnostic, prognostic, and therapeutic criteria.

There is no doubt that the Cobb angle has been, and continues to be, an essential tool in scoliosis evaluation. However, progressive advances in the understanding of spinal deformity biomechanics have shown that an assessment limited to the coronal plane describes only one component of the complex anatomical reality of scoliosis.

Adolescent idiopathic scoliosis (AIS) is not a two-dimensional deformity, but rather a three-dimensional disorder in which lateral spinal deviation represents only one component. It is associated with vertebral rotation and torsion, alterations in trunk balance, modifications of thoracic morphology, and consequent biomechanical adaptations involving the entire spine.

All these elements are closely interconnected and contribute to determining the true severity of the deformity.

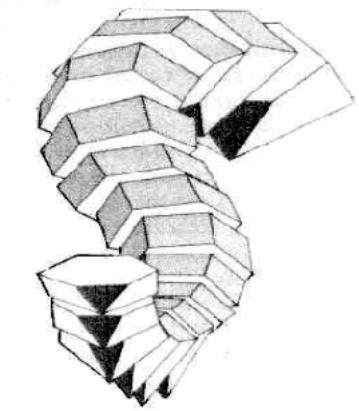


**Figure 4** *Three-dimensional qualitative representation of the spine (Graf et al., 1983)*

Clinical experience consistently demonstrates that two patients with the same Cobb angle may present profoundly different clinical conditions in terms of aesthetic appearance, function, and biomechanics.

In many cases, these differences are determined by the variable degree of vertebral rotation and torsion, essential components of the deformity that cannot be adequately represented by measurement of the Cobb angle alone.

This observation led me to critically reconsider the role attributed to the Cobb angle in the overall assessment of scoliosis. Although it remains an indispensable parameter, in my opinion it cannot independently express the complexity of the deformity or accurately represent its clinical severity.

I therefore reached the conclusion that vertebral torsion should not be considered a secondary or accessory feature of scoliosis, but rather one of the principal determinants of its progression and clinical impact.

For this reason, I believe that a truly representative assessment of deformity must integrate the angular component with the rotational component, overcoming the limitations of a purely two-dimensional analysis.

From this reflection, developed throughout my clinical, surgical, and scientific experience, arose the need to identify a parameter capable of describing scoliotic deformity more comprehensively by integrating its angular, rotational, and torsional aspects.

This concept represents the foundation of the **Global Curve Index (GCI),** which I propose as a new tool for scoliosis assessment, with the aim of providing a more accurate representation of its three-dimensional complexity and true clinical severity.

# THE EVOLUTION OF SURGICAL THINKING: FROM KING TO LENKE AND THE PERSISTING UNRESOLVED CHALLENGES IN SCOLIOSIS ASSESSMENT

In 1983, King and colleagues published a classification of thoracic curves in adolescent idiopathic scoliosis (AIS), identifying five different patterns of deformity to be considered in planning spinal fusion procedures.

This classification represented a fundamental step forward in the evolution of surgical treatment because it demonstrated that curves appearing similar according to Cobb angle measurement could require different surgical strategies.

However, the King classification remained essentially based on the evaluation of deformity in the coronal plane and was closely related to the corrective potential of the Harrington instrumentation systems available at that time.

Thoracolumbar curves and many more complex deformities were not adequately represented, and the rotational component of scoliosis had not yet assumed a decisive role in classification.

Despite these limitations, the King classification had the great merit of demonstrating that Cobb angle measurement alone was insufficient to describe the complexity of scoliotic deformity and that surgical planning required a more comprehensive assessment.

A further and decisive advancement occurred in 2001, when Lenke and colleagues introduced a new classification system for adolescent idiopathic scoliosis.

The Lenke classification identified six curve types associated with lumbar and sagittal modifiers, substantially expanding the assessment criteria compared with the King system. With the Lenke classification, deformity was no longer analyzed exclusively in the coronal plane; evaluation of the sagittal profile was also incorporated.

Furthermore, structural curves were defined according to their behavior during bending radiographs, overcoming a classification system based solely on Cobb angle magnitude.

Lenke's contribution is universally recognized as one of the most important advances in modern scoliosis surgery because it acknowledged the need for a more complete interpretation of spinal deformity. Nevertheless, even this classification system does not completely resolve the challenge of three-dimensional scoliosis assessment.

The rotational and torsional components, which represent some of the most distinctive characteristics of scoliosis, still lack a simple, reproducible, and clinically applicable quantitative parameter.

It is noteworthy that the original authors, in their landmark 2001 publication, acknowledged the difficulties associated with assessing axial deformity through biplanar radiographs.

In the absence of a simple, reliable, and universally accepted method for quantifying scoliosis in all three dimensions, they concluded that two-dimensional radiographs, obtained in the coronal and sagittal planes, should remain the diagnostic standard.

This acknowledgement, originating from the authors of the Lenke classification themselves, confirms that the problem of three-dimensional quantification of adolescent idiopathic scoliosis remains largely unresolved.

It is precisely from this consideration, developed and consolidated through my clinical and surgical experience, that the need emerged to identify a parameter capable of integrating the angular component with the rotational component, thereby providing a more faithful representation of the true severity of deformity: the Global Curve Index (GCI).

# THE NEED FOR AN INDEX INCORPORATING TORSION

My proposal originated from these considerations.

In my opinion, the Cobb angle remains an indispensable tool and cannot be disregarded. However, by itself, it can no longer be considered sufficient to describe the true severity of scoliosis.

My clinical experience, accumulated through more than forty years of professional activity and the long-term follow-up of numerous patients treated both conservatively and surgically, has led me to believe that any meaningful assessment of scoliosis must include the torsional component of the deformity.

Vertebral torsion is, in fact, the element that most directly determines rib prominence, trunk asymmetry, and the aesthetic impact of scoliosis. It is frequently the first clinical sign perceived by the patient and family and often represents the parameter that most accurately reflects the true clinical severity of the deformity.

For this reason, I considered it necessary to identify a simple index that would not disregard vertebral rotation and that would allow radiographic findings to be integrated with clinical assessment.

**THE GLOBAL CURVE INDEX (GCI)**

I therefore propose the following index:

GCI = Cobb angle × Rib prominence magnitude (cm)

The Global Curve Index (GCI) was developed from the need to integrate the traditional measurement of lateral spinal deviation with assessment of the rotational component, clinically expressed by the magnitude of rib prominence.

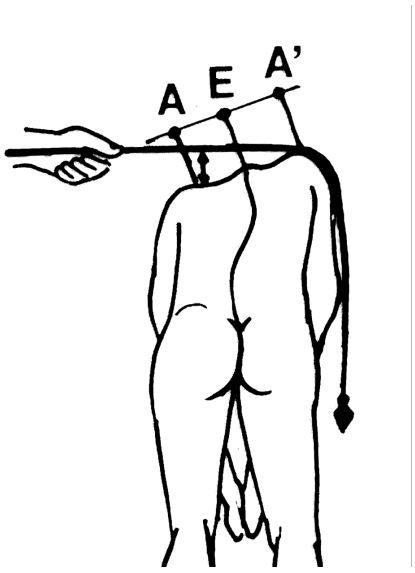



**Figure 5** *Rib hump measurement (Stagnara 1985)*

The purpose of the GCI is to provide a simple, reproducible, and immediately applicable clinical parameter capable of representing the true severity of scoliotic deformity more comprehensively.

I believe that this index may be useful both for monitoring scoliosis progression over time and for evaluating the effectiveness of conservative and surgical treatments.

The GCI finds its most significant application in thoracic and thoracolumbar scoliosis, in which vertebral rotation becomes clinically evident through deformation of the rib cage and the presence of rib prominence, allowing direct assessment of the torsional component.

However, I believe that this method may also be extended to lumbar scoliosis.

In these cases, in the absence of rib prominence, the rotational component may be assessed by measuring asymmetry of the paravertebral masses, allowing longitudinal evaluation of deformity progression at the lumbar level as well.

This approach makes it possible to integrate, within a single parameter, the angular and rotational components of scoliosis, with the objective of providing a more accurate representation of its three-dimensional complexity and clinical relevance.

# PERSONAL EXPERIENCE

## Clinical validation of the Global Curve Index: more than twenty years of follow-up in the same patient

To document the potential clinical value of the Global Curve Index (GCI), I present a clinical case that I had the opportunity to follow personally for more than twenty years.

This case concerns a patient initially evaluated during adolescence, for whom I was able to document the complete evolution of the deformity through periodic clinical assessments, serial radiographic examinations, and observational records inspired by the Stagnara spinal assessment charts (Fiches de Rachis), This method, routinely used at the Centre des Massues in Lyon, was subsequently adopted throughout my professional career, which began with an extended fellowship under the supervision of Pierre Stagnara at the Centre des Massues in 1974.

The relevance of this case derives not only from the characteristics of the deformity itself, but primarily from the continuity and consistency of the clinical observation.

I personally followed every stage of the patient's diagnostic and therapeutic pathway: from the initial evaluation at fifteen years of age, through conservative treatment with a Lyon brace, to scoliosis progression during adulthood, subsequent surgical correction, and long-term postoperative follow-up.

The availability of such extensive and homogeneous clinical documentation, collected by the same observer over a period exceeding two decades, represents a particularly valuable opportunity.

It allows direct comparison between the evolution of the Cobb angle, vertebral rotation, and the Global Curve Index, making it possible to assess whether the latter may more accurately describe the actual clinical progression of the deformity.

This case therefore represents not only an application of the GCI, but also a clinical evaluation of its ability to integrate the angular and rotational components of scoliosis, providing a more comprehensive representation of its long-term evolution.

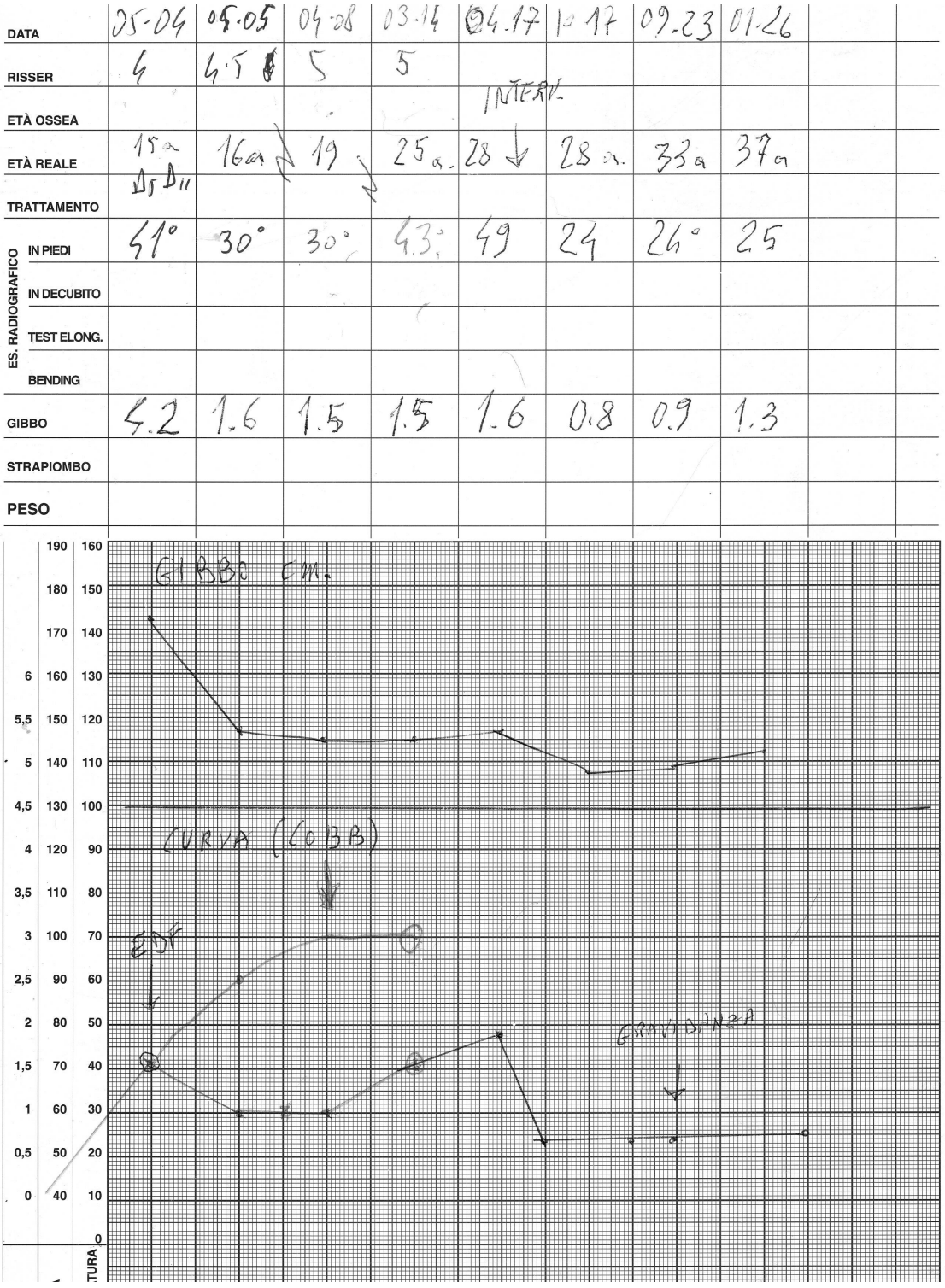



**Figure 6** ***Patient scoliosis progression assessment sheet***

**Clinical data derived from longitudinal follow-up**

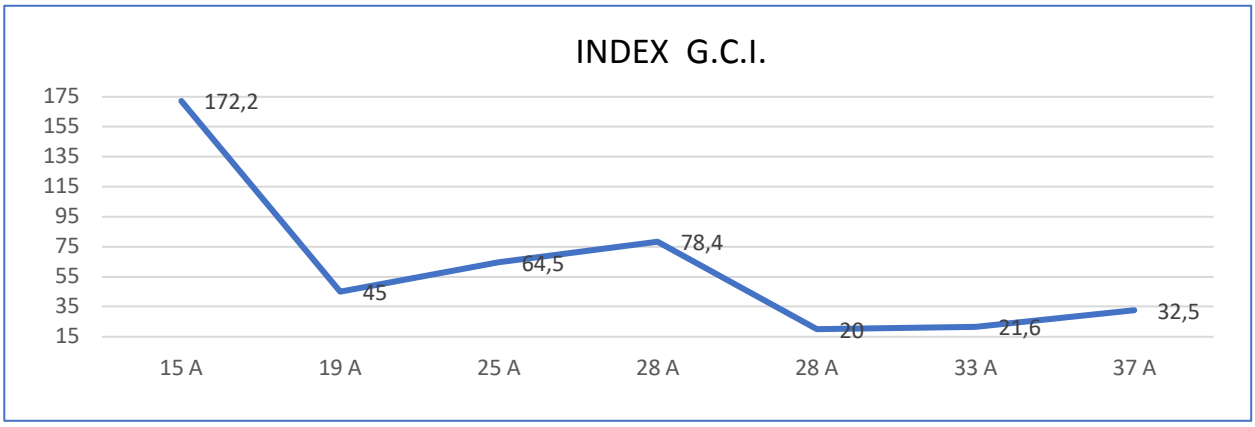
The following parameters were obtained from the patient's clinical records:

- **At 15 years of age:**
  **Cobb angle: 41°; rib prominence: 4.2 cm.**
  **At this stage, an estimate of the expected natural progression of the untreated deformity predicted that the curve could potentially reach a maximum threshold of approximately 70° Cobb.**
- **At 19 years of age (after completion of Lyon brace treatment):**
  Cobb angle: 30°; rib prominence: 1.5 cm.
- **At 25 years of age:**
  Cobb angle: 43°; rib prominence: 1.5 cm.
- **At 28 years of age (preoperative evaluation):**
  Cobb angle: 49°; rib prominence: 1.6 cm.
- **At 28 years of age (postoperative evaluation):**
  Cobb angle: 24°; rib prominence: 0.8 cm.
- **At 33 years of age:**
  Cobb angle: 24°; rib prominence: 0.9 cm.
- **At 37 years of age (during pregnancy):**
  Cobb angle: 25°; rib prominence: 1.3 cm.

Using these data, the clinical evolution of the deformity can be reconstructed according to the Global Curve Index (GCI).

| Years | GCI |
|---|---|
| 15 a. (initial examination)! | 172.2 |
| 19 a. (end of Lyon brace treatment) | 45 |
| 25 a. (progression) | 64.5 |
| 28.a (preoperative assessment) | 78.4 |
| 28.a (preoperative assessment) | 19.2 |
| 33 a. (5 years after surgery) | 21.6 |
| 37 a. (after pregnancy) | 32.5 |

This can be represented by a graph of the following type:




Another graph can be used to compare the Cobb angle measurements, the magnitude of rib prominence, and the G.C.I

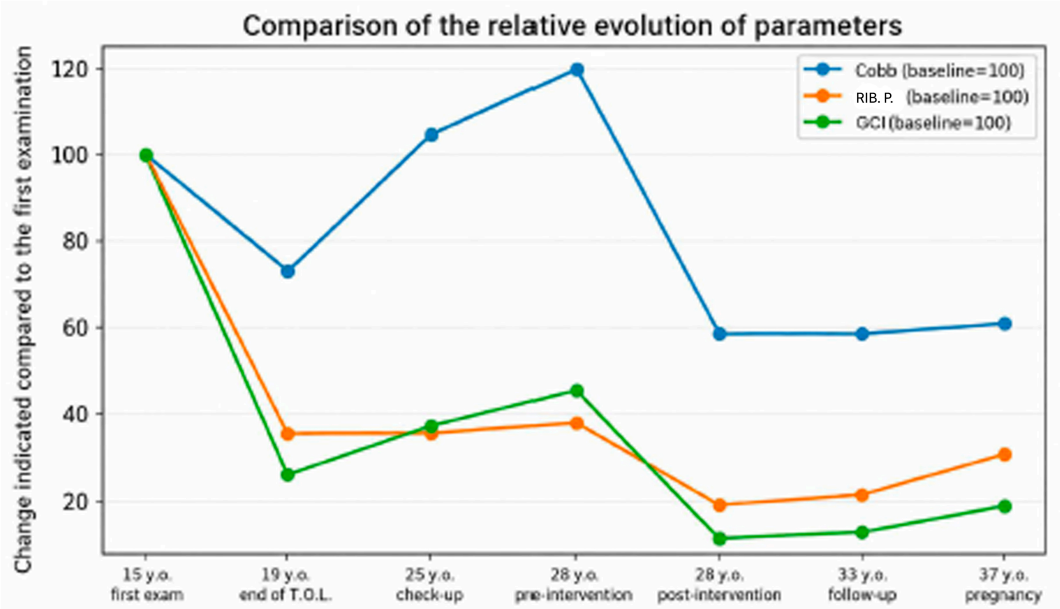



**Figure 7***: Evolution of the Global Curve Index over time*

A further graphical representation may compare:

- Cobb angle progression;
- rib prominence variation;
- Global Curve Index trend.

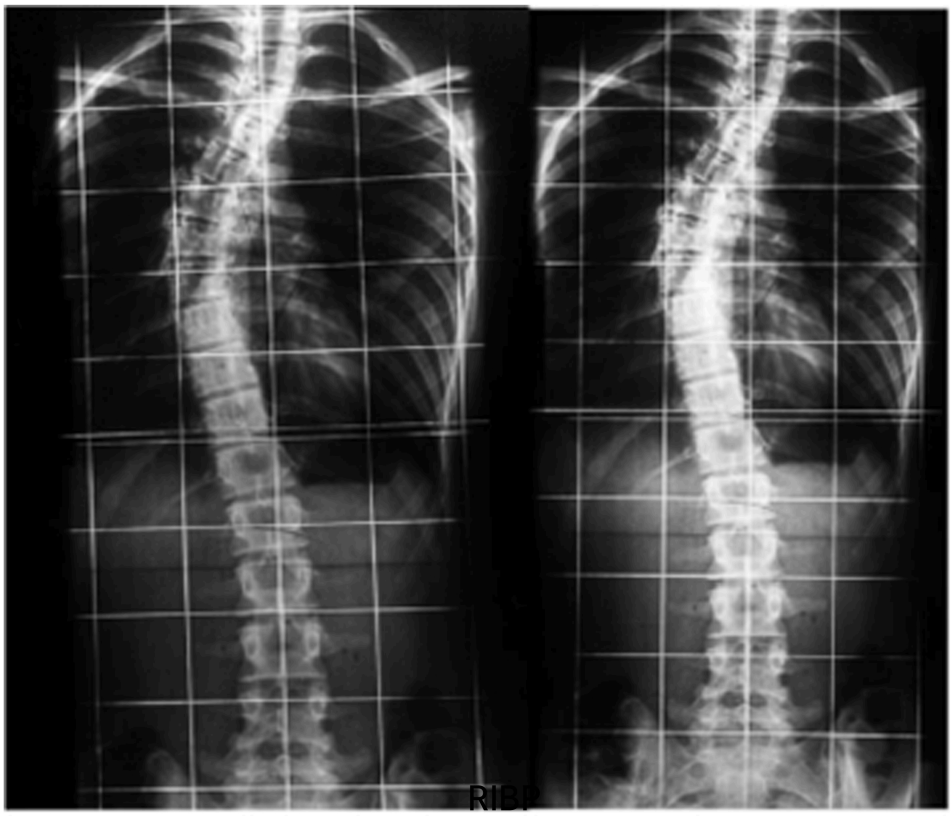
# Clinical interpretation of the longitudinal evolution

The curves represented in this graph demonstrate the ability of the GCI to effectively describe the clinical evolution of the deformity throughout the different phases of the patient's history:

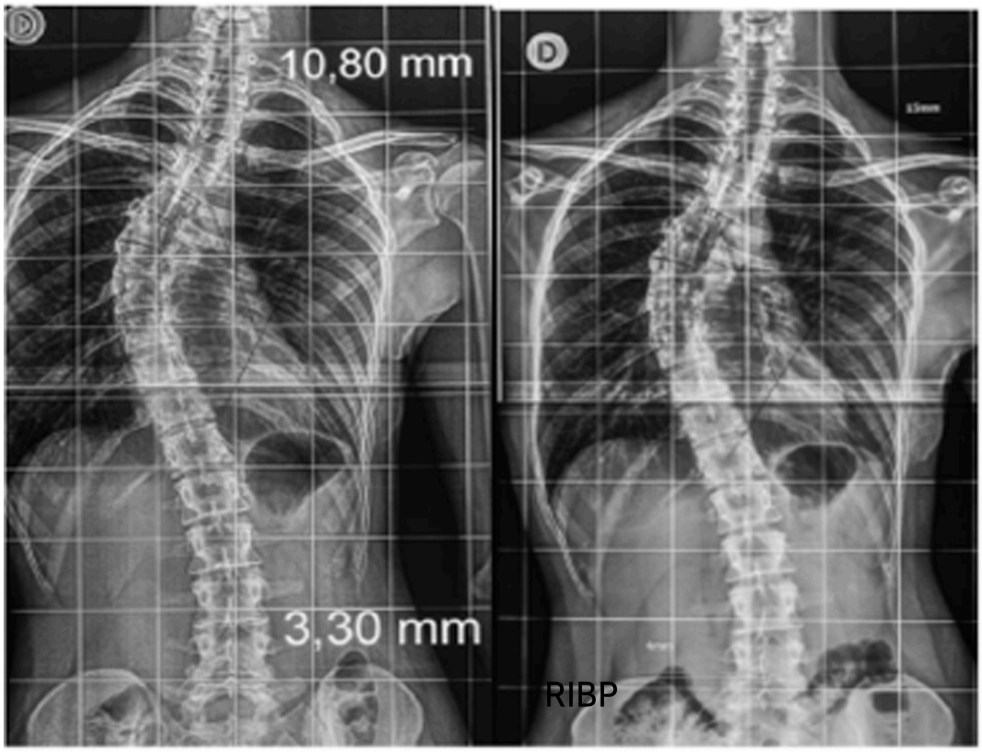
- initial evaluation;
- conservative treatment;
- progression during adulthood and subsequent surgical correction; (Surgical intervention following curve progression in adulthood.
- long-term follow-up after pregnancy.

A particularly relevant observation emerges from the serial assessment of vertebral torsion through gibbometry.

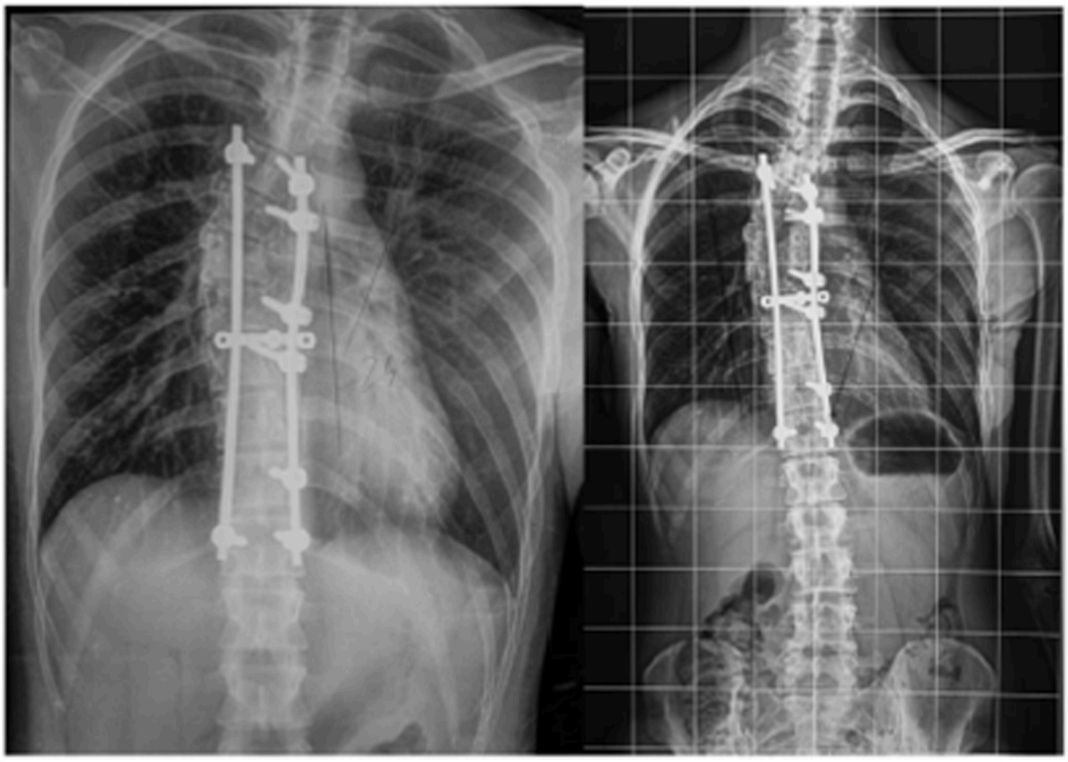
At the initial evaluation, torsional deformity was expressed by a rib prominence of 4.2 cm. During the entire subsequent course of the deformity, this parameter remained substantially stable, consistently below 2.0 cm, despite significant variations in the Cobb angle.




15 a. 41° RIB. P. 4,2 (GCI 172,2) > **T.O.L.** 19 a. 30° RIB. P.1,5 (GCI 45)




25 a. 43° RIB. P.1,5 (GCI 64,5). >28 a. 49° RIB. P.1,6 (GCI 78,4) > SURGERY



28 a. 24° RIB. P. 0,8 (GCI 20) >

33 a. 24° RIB. P. 0,9. (GCI 21,6)



37 a. (Pregnancy) 25° RIB. P. 1,3 (GCI 32,5)

GCI

| | |
|---|---|
| 15 a. 41° | 172,2* |
| T.O.L. | |
| 19 a. 30° | 45* |
| 25 a. 43° | 64,5* |
| 28 a. 49° | 78,4* |
| SURGERY | |
| 28 a. 24° | 20* |
| 33 a. 24° | 21,6* |
| 37 a. 25° | 32,5* |

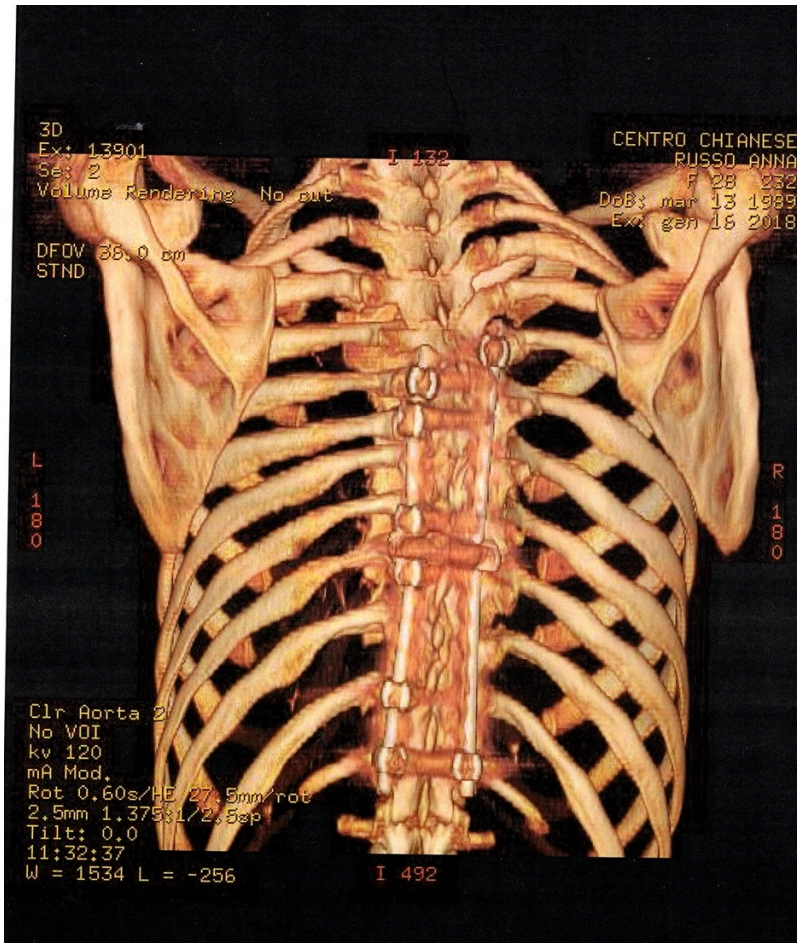



**Figure 8** ***Visualization of Arthrodesis - 19-Year Follow-Up***

Note the mild left-convex cervicothoracic compensatory curve, which balances the residual thoracic curve and results in good shoulders alignment. - Shoulder Sign - (Kuklo T.R. 1976)

The most significant aspect of this clinical observation is that, despite the relevant changes observed over time in the Cobb angle, the torsional component of the deformity, assessed through gibbometry, remained essentially unchanged.

This apparent discrepancy demonstrates that the isolated evolution of the Cobb angle is not always sufficient to accurately represent the progression of scoliotic deformity.

Scoliosis does not evolve exclusively in the coronal plane; it simultaneously involves vertebral rotation, trunk balance, and sagittal alignment, all of which contribute to defining its true clinical expression.

This experience further reinforced my conviction that scoliosis assessment should be based on an integrated analysis of its different components: lateral spinal deviation, sagittal curve behavior, and, above all, rotational deformity expressed clinically through vertebral torsion.

The Global Curve Index (GCI) was developed precisely in response to this need.

Its objective is to integrate, within a simple, reproducible, and easily applicable clinical parameter, the angular and rotational components of deformity, providing clinicians with an additional tool for

interpreting natural history, monitoring progression, and evaluating therapeutic outcomes more accurately.

In my opinion, the principal value of the GCI does not lie in replacing traditional parameters, but rather in complementing them, thereby contributing to a more faithful representation of the three-dimensional complexity of scoliosis and its true clinical severity.

## DISCUSSION

The assessment of scoliosis severity remains one of the most debated and complex issues in the management of spinal deformities.

Since its introduction, the Cobb angle has represented the cornerstone of scoliosis evaluation, providing a simple, reproducible, and universally accepted method for quantifying coronal plane deformity. Its historical importance is undeniable, and it continues to play a fundamental role in clinical decision-making, treatment indication, and postoperative evaluation.

However, the progressive understanding of scoliosis as a three-dimensional deformity has highlighted the intrinsic limitations of an evaluation system based predominantly on a single two-dimensional parameter.

Adolescent idiopathic scoliosis is characterized not only by lateral deviation of the spine, but also by vertebral rotation, axial torsion, alterations in thoracic morphology, and modifications of global spinal balance. Among these components, vertebral torsion represents a particularly relevant element because it directly influences trunk asymmetry, rib prominence, aesthetic perception, and the clinical expression of the deformity.

Although several classification systems and imaging techniques have significantly improved scoliosis assessment, the development of a simple, reproducible, and clinically applicable parameter capable of integrating coronal deformity and rotational imbalance remains an unresolved challenge.

**The Global Curve Index (GCI) was conceived in response to this clinical need.**

The rationale underlying this index is that the severity of scoliosis cannot be adequately represented by angular measurement alone; it should also incorporate the rotational component of deformity, which is clinically expressed by rib prominence or, in lumbar curves, by paravertebral asymmetry.

By multiplying the Cobb angle by the measured magnitude of rotational deformity, the GCI provides an integrated numerical value intended to better reflect the overall clinical burden of the deformity. The purpose of the GCI is not to replace established parameters such as the Cobb angle, nor to challenge validated classification systems, but rather to provide an additional complementary tool capable of enhancing clinical interpretation.

The longitudinal clinical observation presented in this study supports the concept that variations in the Cobb angle do not always correspond proportionally to changes in the rotational component of scoliosis.

This finding suggests that the angular progression of a curve and the evolution of its three-dimensional deformity may follow partially independent patterns.

Therefore, an assessment incorporating both components may provide a more comprehensive representation of the clinical behavior of scoliosis.

The simplicity of the GCI represents one of its potential advantages.

Unlike advanced three-dimensional imaging techniques, which may provide detailed anatomical information but are limited by cost, availability, radiation exposure, or lack of routine applicability, the GCI can be calculated using parameters already available in standard clinical practice.

The index combines a radiographic measurement with a clinical assessment, allowing repeated evaluation during follow-up without additional diagnostic burden.

Further prospective studies involving larger patient cohorts will be necessary to validate the reproducibility, reliability, and prognostic value of the GCI.

Future investigations should determine its correlation with established classifications, patient-reported outcomes, progression risk, and postoperative results.

Nevertheless, the conceptual basis of the GCI arises from a fundamental clinical observation: scoliosis is not merely an angular deformity, but a complex three-dimensional disorder in which rotation and torsion play a central role.

## CONCLUSION

After decades dedicated to the study and treatment of spinal deformities, **I propose the Global Curve Index (GCI) as a new parameter for the assessment of idiopathic scoliosis.**

The GCI is based on the integration of two essential components of the deformity:

- the angular deviation of the spine, expressed by the Cobb angle;
- the rotational component, clinically represented by rib prominence or paravertebral asymmetry.

This approach reflects the three-dimensional nature of scoliosis more accurately than a purely coronal evaluation.

The aim of the GCI is not to replace traditional assessment methods, which remain fundamental, but to complement them by introducing a simple, reproducible, and clinically applicable measure that may provide a more complete understanding of deformity severity.

The experience gained through long-term clinical observation suggests that incorporating torsional assessment into scoliosis evaluation may offer additional information regarding natural history, progression, and treatment response.

The Global Curve Index therefore represents my proposal for a more comprehensive evaluation of idiopathic scoliosis, based on the principle that the true severity of spinal deformity can only be understood through an integrated analysis of its three-dimensional components.

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