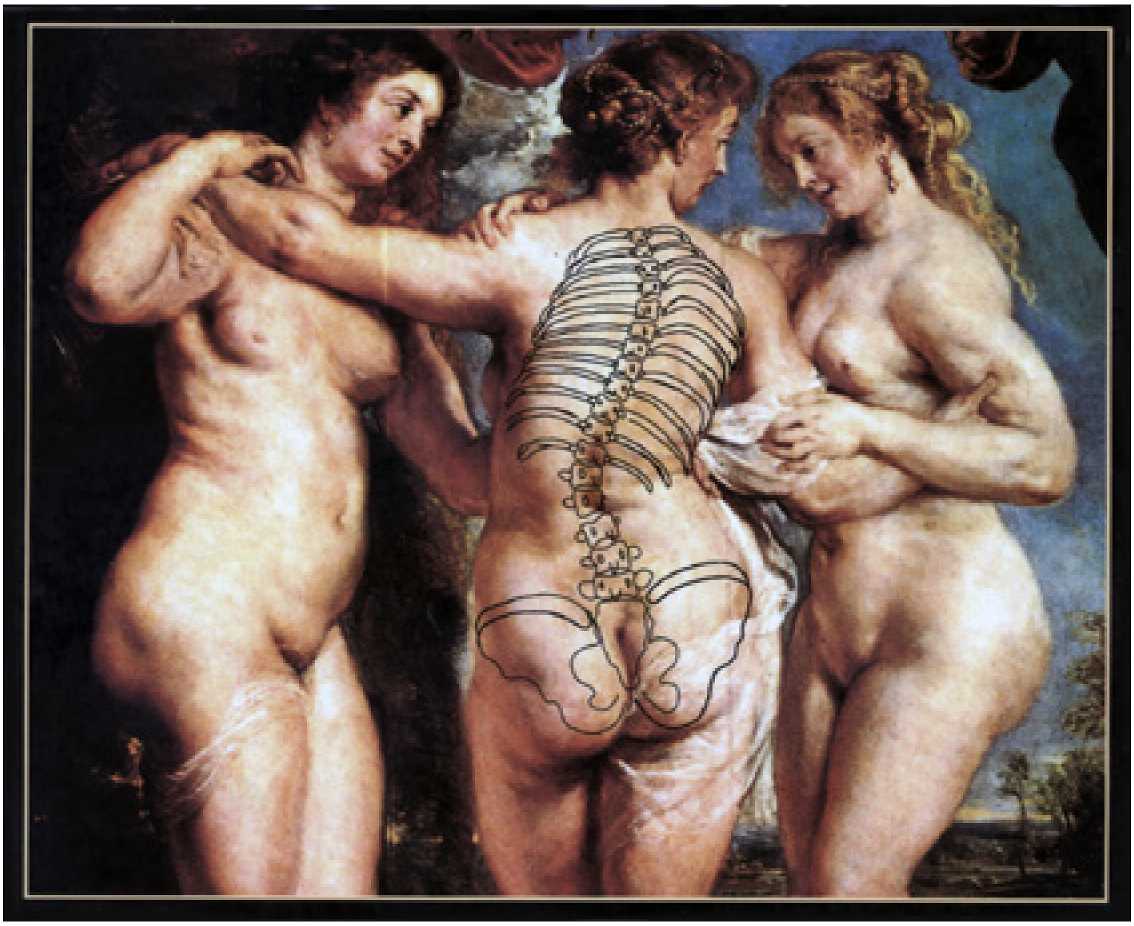
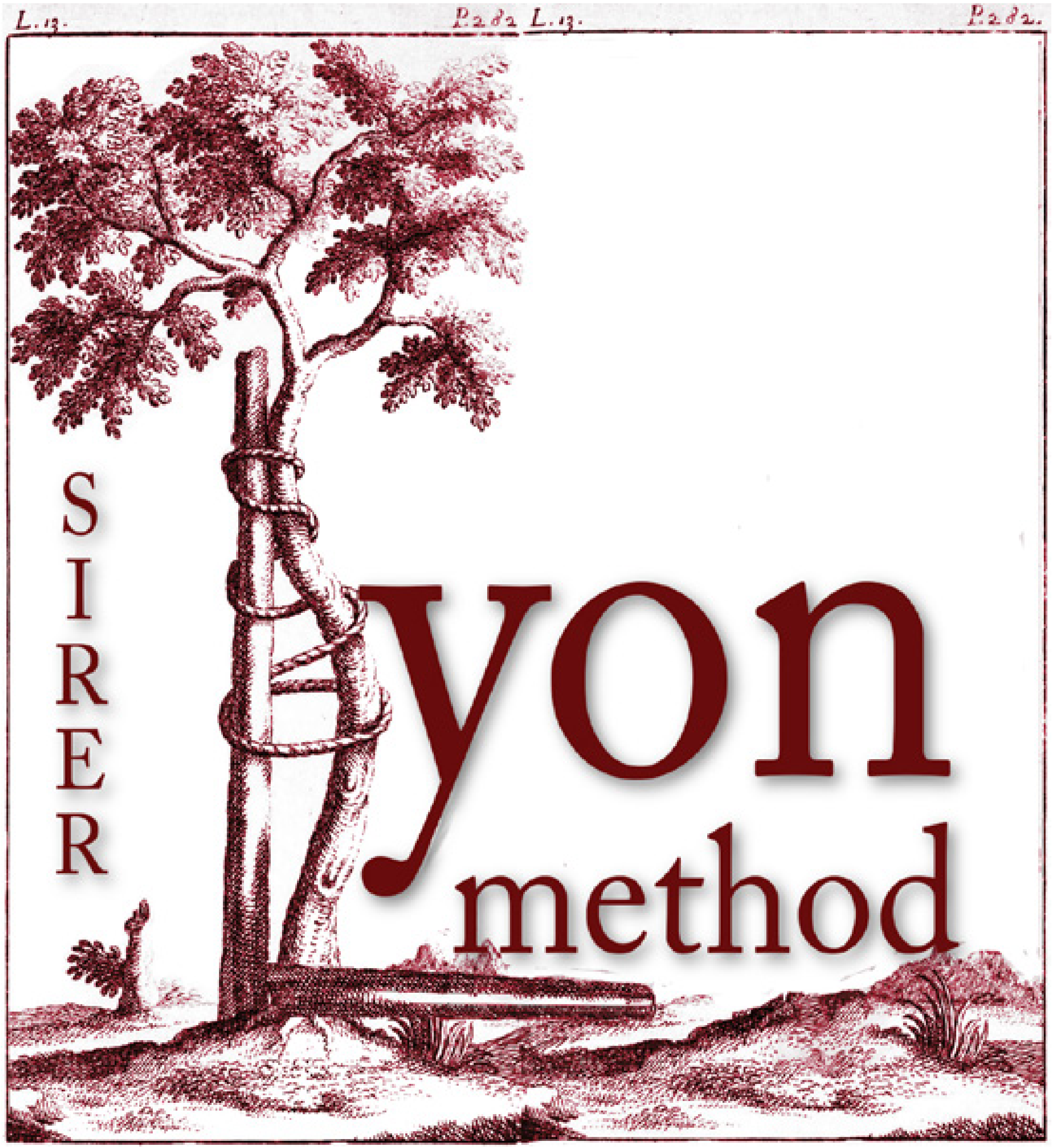
# Non surgical treatment of Scoliosis and other Vertebral Deviations:

# Lyon method



*Edited by Danielle Vernon, PT*

**Jean Claude de Mauroy, Fabio Gagliano**








# Preface to the third edition

It's not a perfect view of the conservative, non-surgical treatment of scoliosis to consult only a few research publications of varying levels of evidence on physiotherapy and braces.

It's true that the justification for this treatment is paradoxical. Worldwide, there have never been so many physiotherapists and orthoprosthetists taking on these treatments at the request of patients. But there has never been so much confusion over the interpretation of the results of these treatments, and the multiplication of Randomised Control Trials seems illusory. So, it's not enough to keep publishing research, it's time to synthesize it and link the various publications to the search for the simplest possible method of carrying out these conservative treatments.

This has been the aim of the Lyon Method ever since Pravaz's initial publications 200 years ago. Many colleagues have been inspired by this method, and we're very honored. Away from the chapels of knowledge transmission by imitation of practice (the how), we have developed an online certification based on the mechanisms of knowledge, enabling each therapist to build his or her own exercise or brace.

It is to be hoped that this new edition will be as well received as the one published in 1996, but those who wish to compare them will easily see how different this one is from the first.

The form has been preserved, many innovative concepts have been added, and advances in publishing technology have enabled much more abundant color illustration. In fact, this is a new reference work intended primarily for certification students, but also for all those who specialize in the treatment of scoliosis.

The Lyon Method is alive and well, keeping pace with technological developments and the changing medical environment, but never betraying its illustrious predecessors from Pravaz to Stagnara and Mollon. After 50 years of clinical practice in scoliosis, and after much reading and re-reading, there is a continuity that is matched only by the frequency of idiopathic scoliosis, despite all the research undertaken to date.

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*To all scoliosis enthusiasts and especially to those who have wished to be certified, this summary of 50 years' experience is for them. This book should add a cultural dimension to the wealth of scientific knowledge acquired.*

*Jean Claude de Mauroy*





# Tribute from the author

Of course, almost 75 years after Pierre STAGNARA perfected the conservative orthopedic treatment of scoliosis in Lyon, it was important to revisit it and pass on the practical experience acquired over half a century. This treatment is currently proving «effective» on a large scale and over the long term in almost all cases of idiopathic scoliosis discovered at an early stage, enabling scoliosis to be stabilized without the need for surgery. The fitting of such a treatment requires perfect collaboration between the doctor, the orthotist, and the physiotherapist. The relative rarity of scoliosis (around 1,400 idiopathic scoliosis requiring orthopedic treatment in France every year) justifies this book, written by a specialized team working in France and Italy.

*Dr Jean Claude de Mauroy has devoted his entire medical career to developing the Lyon Method, created 200 years ago by Pravaz. This book is a revised, corrected and updated edition of the book published in 1996 under the title «La scoliose; Traitement Orthopédique conservateur».*

Of course, we know more and more about the anomalies of the scoliotic spine, and we're even able to reproduce scoliosis by modifying certain factors. We know how to analyze it in space, describe it, characterize it, type it. The images provided by radiologists' computers are increasingly beautiful, precise, and three-dimensional. The braces used by orthotists in the field of orthopedics are increasingly light, effective, and aesthetically pleasing.

In medical literature, articles combine the term scoliosis with many other medical terms. In fact, we are still unable to predict the evolution of a child who consults us for a small deviation. We are only able to limit the damage with orthopedic and surgical treatment once the tragedy has occurred. Large-scale screening operations have not reduced the rate of surgical intervention in the North American states where they have been carried out. The result is growing dissatisfaction and a sense of impasse. We know most of the physical laws governing scoliosis. We've reached a point where, if we carry on as we are, we'll have to spend huge sums of money on research whose results we can't predict.

What if we were wrong and accepted the obvious: it's impossible to predict the progression of scoliosis, and it's impossible to cure scoliosis once the progressive process has begun.

Of course, the evolution of some scoliosis is linear, but what if the evolution of scoliosis wasn't? In other words, what would happen if we applied chaos theory to scoliosis?

In recent years, many scientists have encountered the same difficulties as scoliologists. According to James Gleick, «A theoretical representation of the transition to turbulence is beginning to emerge, the core of chaos is mathematically accessible. Chaos now predicts a future that no one can deny. But to accept this future, we must renounce the essentials of the past». In 1986, in the huge Masur Auditorium of the National Institute of Health in suburban Washington, the first major conference on chaos in biology and medicine was held. From the erratic eye movements of schizophrenics to ventricular fibrillation, from biological clock misalignments to artificial intelligence, chaos theory provides a tool for detecting the fundamental element of life in irregularity.

Man's verticality has shifted the center of gravity away from the ground, as in the case of the tower, as opposed to the classic single-story building. Scoliosis is the visible consequence of an earthquake that weakens the concave part of the posterior wall of the vertebral body. As far as scoliosis is concerned, it is impossible to predict the eventuality and intensity of an earthquake, even if we know the areas at risk, and in particular pubertal growth.

For the doctor, the consequences are obvious. They believe:
- Let's keep a close eye on these children, who are showing some early signs of an earthquake, without trying to play the sooth-sayer.
- Let's reinforce all the construction elements with physiotherapy as soon as we are in a high-risk phase.
- when aesthetics and common sense allow, let's use the brace from the start.
-after the earthquake, if the building has not completely collapsed, let's immediately reinforce it with the brace, because in scoliosis too, we see «aftershocks» with continuous collapse at vertebral level, but also at the level of the upper and lower vertebrae.

Scoliosis is a complex sinuous frontier between stability and instability, where linear models are no longer valid. The future may lie in the search for an unknown attractor of fractal dimension, but the present is our children with scoliosis. Let's look at them, monitor them, protect them, and stop wondering needlessly whether physiotherapy or orthopedic treatment modifies the natural evolution of scoliosis.

*"I dedicate this book to Pierre Stagnara. I felt him at my side throughout the writing process. May it find us beyond the death that separates us, the expression of my friendly loyalty."*

*Lyon, August 18, 1996 & 2023*
*Jean-Claude de MAUROY*





# Preface by Charles Picault

There was a blueprint for the treatment of scoliosis: orthopedic treatment was authorized only for curves classified as "progressive", and this character was granted only to those exceeding 20-25°. Surgery was envisaged only for those exceeding 55-60°. Were the deviations discovered later? Were evolutionary potentials increased by a lack of vitamins, a lack of sunlight, a lack of sport? In any case, spontaneous evolution was recorded in the manner of entomologists.

Physiotherapy was being created and structured; teachers were highly competent; schools were opening up; chapels were appearing. Countless studies have analysed a multitude of criteria surprised during aggravation, and have attempted in vain to correlate them: angle, rotation, torsion, bone maturation, growth potential... After decades of controversy, the same widespread disappointment is evident. Nobody can answer the question: what are the criteria for the evolution of scoliosis? or, to put it another way, what are the criteria for the success of conservative treatment?

Jean Claude de Mauroy, with over twenty years' experience, takes stock of the situation and asserts that it is unacceptable to wait too long to do something. But in 1996, he noted, with an exhaustive bibliography, that there was still no consensus. As a result, systematic screening for vertebral deviations was abandoned in the USA, Canada, Japan and France. Faced with this inability to predict, the author proposes the notion of chaos, taken from meteorological science; with numerous but subtle warning signs, it is impossible to predict the moment when the deviation is triggered; we can no longer accept to passively witness its inevitable worsening.

Physiotherapy has a long tradition. Statistics are also lacking in this field. Physiotherapy can be used in isolation, as part of a highly selective approach to treatment in which the clinic plays a key role. It can be combined with a brace, which should be used very early on to ensure that it is effective, not restrictive and as inexpensive as possible.

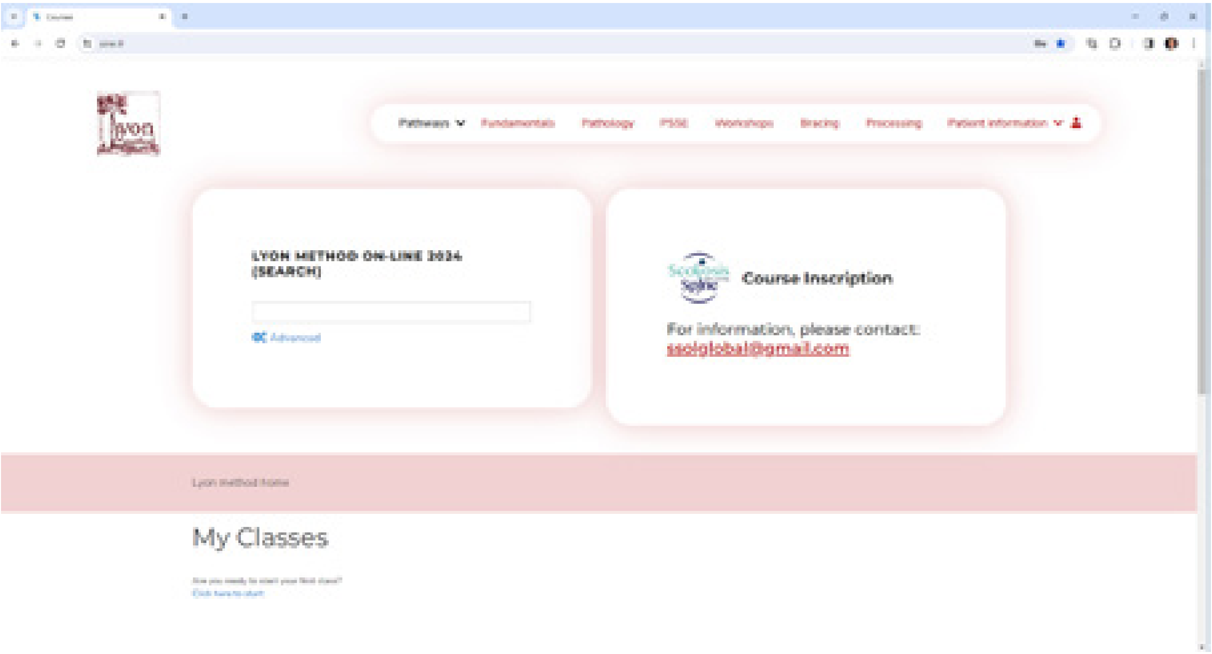
"Kai ta scolia eis eroteian" and what is twisted will be straightened, was the motto of Pierre Stagnara, to whom this book is rightly dedicated.

In 1741, with the title "L'orthopédie ou 1'art de prévenir et de corriger dans les enfants les difformités du corps", Nicolas Andry gave all the world's orthopedic societies the symbol of the torso tree linked to its stake.

Two interpretations are possible.
Treatment was too late, and the tree, already an adult, will have to assume its deformity or undergo surgical, anatomical and/or psychological correction. Or,
It's a hopeful sign, because this tree, still young but already deformed, will see the aggravation avoided, but will retain a residual curve.

This last perspective may not even be satisfactory today. This book will enable every person dealing with scoliosis to take their own therapeutic direction.

Charles PICAULT

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*Chapter 1*

# 1. From past to future

> ***«We are born for each other; we must avoid having anything shocking, and when one would be alone in the world, it would not be appropriate to neglect one's body to the point of allowing it to become deformed; that would be to go against the very intention of the Creator; it is on this principle that this Orthopedics is founded.»***
>
> **Nicolas ANDRY, Paris 1741**

## History

The history of scoliosis is a little like the history of medicine. It begins with Hippocrates (460-377 BC) who, 400 years before Christ, compiled in the "*Corpus Hippocraticum*" all the medical science of the Cos and Cnidus schools. All vertebral deformities are grouped together under the name Spina-luxata. The association of spinal hump with tuberculosis is well described, but Pott's disease is not differentiated from simple deviations as we know them today.

## EVOLVING KNOWLEDGE OF SCOLIOSIS

A skeleton from the Neolithic period (5000 BC) has been unearthed near Heildelberg in Germany. It was in Sparta that the first law concerning spinal deformities was codified. As for other deformities, a newborn baby suffering from congenital scoliosis was abandoned on the slopes of Mount Taiget. In Rome, the laws of Romulus were almost identical, with the decision being taken by a family council made up of men. However, numerous statues of hunchbacks have been found among the Egyptians, Incas, Greeks and Romans, proving that acquired deformities were well integrated into society. In mythology, the god Priape, son of Dionisos and Venus, has a hump associated with fertility and male virility. The Greek fabulist Aesop (570 B.C.) is represented on this statue in the Torlonia Museum in Rome (Fig1.1).

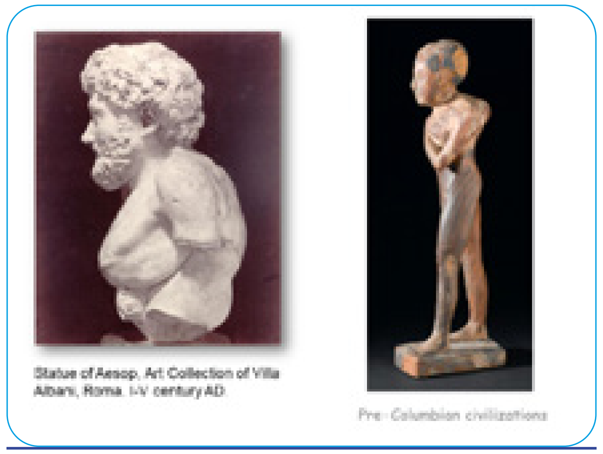



Fig 1.1 Aesop and pre-Columbian civilizations

These are kyphoscoliosis, not lordoscoliosis as we see them today, due to the rarity of poliomyelitis and tuberculosis. Claudius Galen, 200 BC, was an anatomist who described the muscles of the spine and coined the term scoliosis (from the Greek word for tortuous). He advocated medical gymnastics and hydrotherapy. Soranus d'Ephèze distinguished rickets from spinaluxata, but the rarity of this condition in the pelvis meant that it was only much later in England that this etiology was mentioned again.

In the Renaissance, orthopedics had two essential chapters: clubfoot and spinal curve. In 1575, in his 23ème book on orthoses, Ambroise Paré recommended "le corset pour redresser un corps tortueux" (the bra to straighten a tortuous body), a metal corset derived from the armor of the time, which was the first known corset (Fig 1.2). He classifies scoliosis as a spinal trauma and considers it a ligament theory.

Fig 1.2 Ambroise Pare's iron brace

In the 17th century, Francis Glisson of Cambridge, England, in his "Treatise on the Spine" evoked the rachitic origin, and "rachitic scoliosis" was the equivalent of our idiopathic scoliosis until the beginning of the 20the century. The most common cause seems to be rickets in northern European countries. The English term "ricket" derives from the Old French "riquet" meaning hunchback. On the therapeutic level, he recommended suspension and stretching, which were introduced in France under the name of "escarpolette anglaise". Jean Mery notes the concomitant rotation of the scoliotic vertebra.

In 1741, Lyon-born Nicolas Andry coined the term "orthopedics" in his treatise "L'orthopédie ou l'art de prévenir et de corriger les déformations du corps chez les enfants". It was in his book that we find the symbol of orthopedics, the "torso tree" (Fig 1.3).

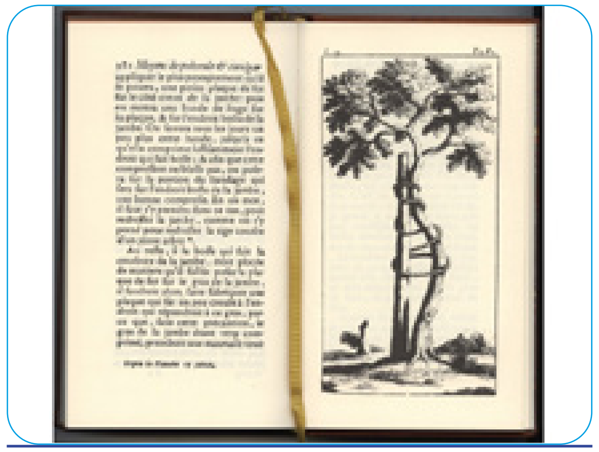


Fig 1.3 Nicolas Andry's torso tree

It emphasizes bad posture and suggests rules of "vertebral hygiene". It would take several years for the term "orthopedics" to catch on, since in 1828 Jacques Mathieu Delpech of Montpellier published a "treatise on orthomorphism", having never heard of the term "orthopedics". In this treatise, he describes the wedge-shaped deformation of vertebral bodies, asserting the structural nature of the deformity. His muscular theory made perfect sense at a time when poliomyelitis was rife.





# 1. NON-SURGICAL ORTHOPEDIC TREATMENTS

He first described an attempt to straighten a hump, dating back to the 5th century, known as Nearchus' epigram. "Zocleo, wanting to straighten Diodoro's hump, placed 3 large square stones at the top of the hump, which caused him to die, but straighter than an I". A few years later, Hippocrates used the "scammon" or bed equipped with winches and pulleys, combining traction and pressure at the hump level (Fig 1.4).

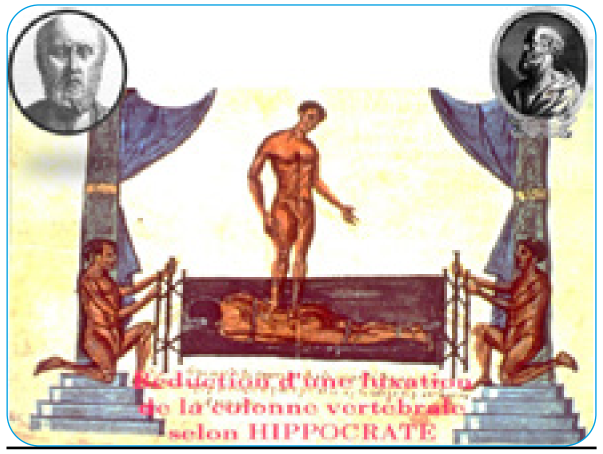



Fig 1.4 Hippocrates' "Scammon

Conservative orthopedic treatment progressed from the Renaissance onwards;
- Acquapendante (1619) looks for a progressive support;
- The first suspension brace was proposed by Francis Glisson in 1677; Guillaume Levacher de la Feutrie, in his treatise on Rakitis, and Johan Kohler depict ilio-cervical extension braces which are the ancestors of the Milwaukee brace (Fig 1.5) .

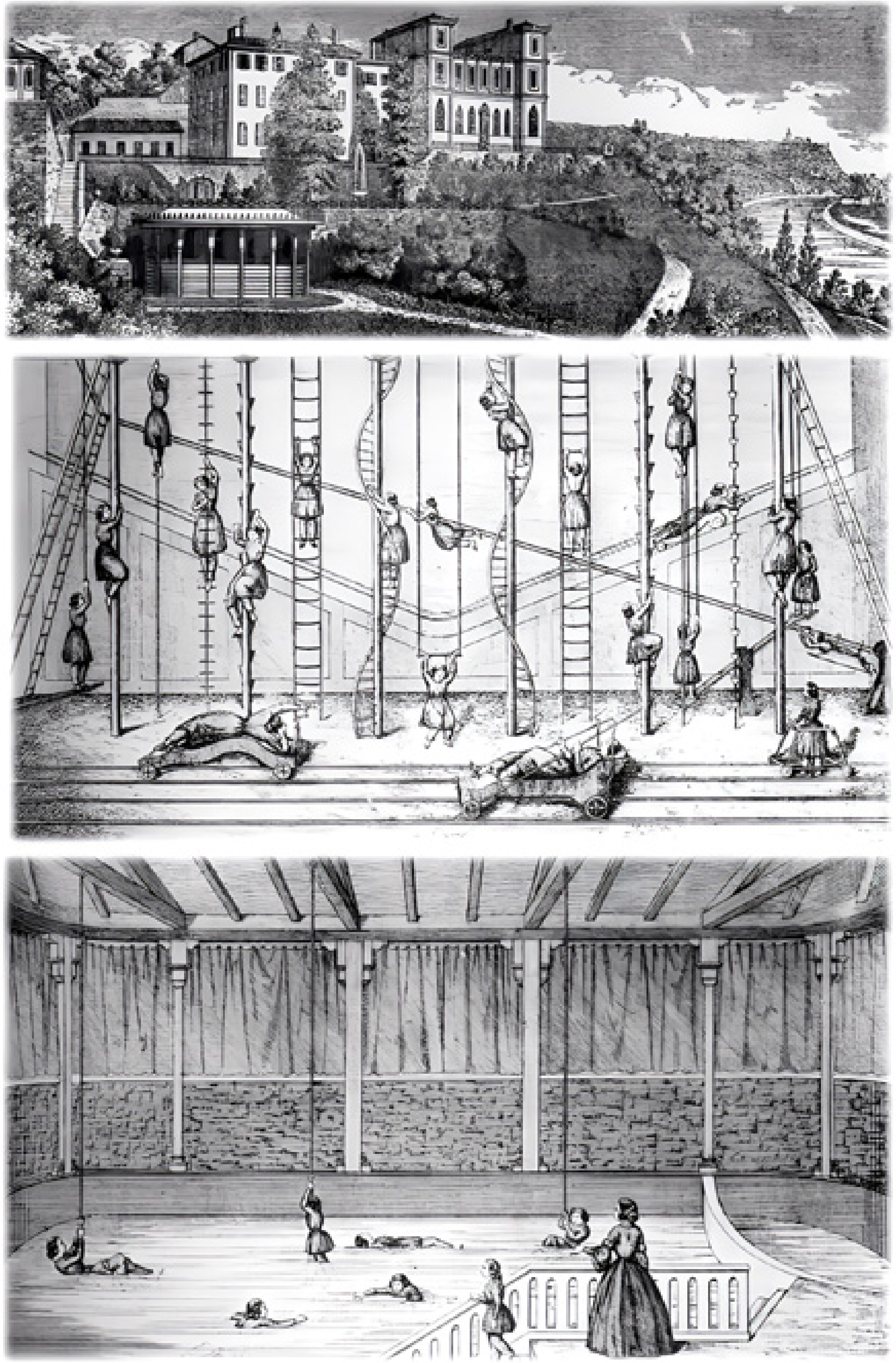
Fig 1.5 Shanz and Milwaukee brace

Axillary contact was proposed by Portal in 1776.

In 1791, Jean André Venel of Geneva proposed the permanent wearing of the device day and night. These braces were modified very little until the early 20th century, as can be seen on this brace by Shanz in 1914 (Fig 1.5). Progress in brace design is also linked to advances in materials.

The medical use of plaster has been known in Europe since the early 19th century. Celluloid appeared in the early 1900s. Around 1960, Plexidur and polyethylene gradually replaced leather, and hard aluminum replaced steel uprights. Modern braces have benefited from the progress made in corsets after the Second World War.

In 1945 Blount and Schmidt proposed the Milwaukee. In 1949, Stagnara produced the first adjustable "underarm" brace, in leather and steel (Fig 1.6).



*Off-text illustration: Engravings from Pravaz's first book published in 1827, showing physiotherapy at the Orthopedic Institute in Lyon.*





*Chapter 2*

# 2. From definition to nosology

**"What's the point of knowing the word if you know the thing?" says one speaker.**

**"It's useful for conversation." - replies another,**

**"Close to us, the thing and the word must be the same thing."**

**concludes the Chairman.** **GES**

## Basic definitions

### Starting age

**Infantile** scoliosis: scoliosis with onset between birth and three years of age, excluding scoliosis due to congenital malformation.

**Juvenile** scoliosis: scoliosis that starts between the age of 4 and the onset of pubertal growth.
Juveniles are further broken down into 3 categories.

Juvenile 1 as 4 - 7 years,
Juvenile 2 as 8 - 10 years,
Juvenile 3 as 11 years – puberty

**Adolescent** scoliosis; seen during pubertal growth and before bone maturity. These are the most common types of scoliosis.

**Adult** scoliosis: any scoliosis that occurs in adulthood after bone maturity

**De novo**: adult scoliosis that appeared in adulthood when there was no curve before puberty.

### Apical vertebra

This is the most eccentric vertebra with the greatest absolute axial rotation.

### A.S.A.L.I.J.

Asymmetric structural Anomaly of the Lumbo-Iliac Junction, described by du Peloux. It corresponds to an asymmetry in the length of the L4 iliolumbar ligaments. (Fig 2.1).

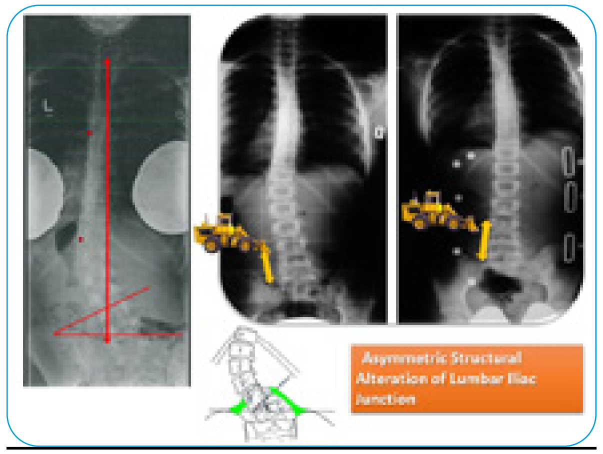



Fig 2.1 Asymmetric structural anomaly of the lumbo-iliac junction

## Bending

This is a lateral tilting movement of one or more vertebrae, seen in the frontal plane.

## Bone age

It is usually determined by an X-ray of the hand and left wrist, compared with the standards of the Greuchlich and Pyle atlas. In scoliosis, the Risser and Sanders tests are also used.

## Café au lait spots

This is a brown pigmented skin area. 7 cafe-au-lait spots are necessary to evoke Recklinghausen neurofibromatosis.

## Center of gravity

It is located in an upright position opposite S2, crossing forward at the level of the L3 pivot vertebra.

## Cobb angle

It is formed by the two corresponding straight lines of the frontal projection on a frontal X-ray, of the limiting vertebrae of a scoliotic curve zone. This measurement can also be used for sagittal measurements.

## Compensation curve

See counter-curve.

## Congenital scoliosis

Scoliosis is caused by an anomaly in vertebral development during pregnancy. This anomaly is generally located at the 4th week of embryonic life (Fig 2.2).

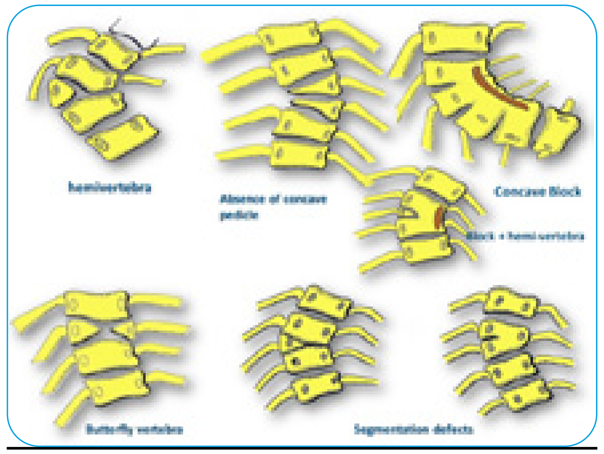



Fig 2.2 Most frequent congenital scoliosis

## Counter curve

This is the curve zone contralateral to the main curve. This zone maintains the alignment of the occipital axis.

## Slope

It's the inclination of a vertebra backwards and downwards in relation to the horizontal and in relation to a vertebra seen in the sagittal plane (as opposed to proclivity).

## Scoliosis de Novo

This is an adult scoliosis that appeared in adulthood when there was no curve before puberty (Fig 2.3).

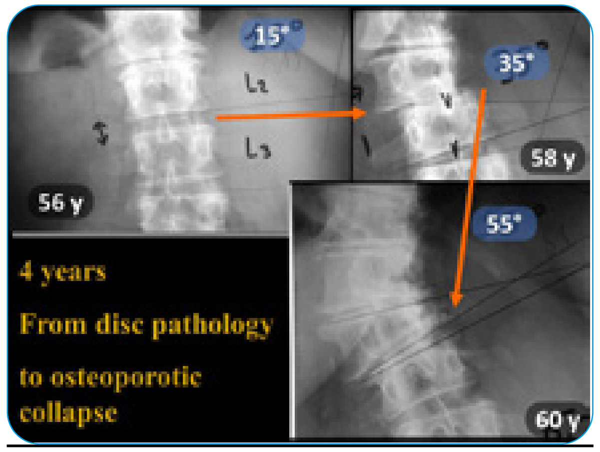



Fig 2.3 Evolution of de novo scoliosis over 4 years

## Dislocation (rotational)

It is a condition in which the homologous points of 2 vertebrae are misaligned by more than 6 mm. It may be rotatory.

## Familial scoliosis

Structural scoliosis runs in the family. The frequency of curves greater than 30° is around 2/1000 of the population, and 2% when one of the first-degree relatives has scoliosis.

## Flat back

A sharp reduction in sagittal curves

## Frontal alignment

Clinically and radiologically, the straight line joining the spinous process of Tl to the spinous process of Sl is vertical. When it is not, we speak of «gite».

## Frontal balance

(See front alignment)

## Functional curve

This is a non-structural counter-curve with no rotation.

## Half curve

This is a counter-curve in which one of the limiting vertebrae is horizontal, while the other is shared with the overlying or underlying curvature zone.

## Idiopathic scoliosis

A structural scoliosis for which no etiology has been found. However, it is accepted that the origin is linked to the spine's balance mechanisms in the upright position. Burwell developed the concept of delayed posture system maturation (NOTOM).

## Ilio-lumbar angle

The angle formed by the line joining the two iliac crests and the line formed by the lower plateau of the lower limiting vertebra of a lumbar scoliosis (Fig 2.4).

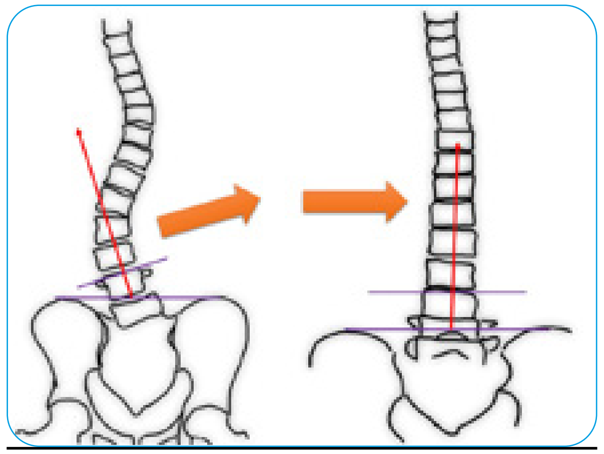


Fig 2.4 Opening the iliolumbar angle

## Incidence (Radiological)

This is the angle between the perpendicular to the sacral plateau at its center and the line joining the center of the sacral plateau and the center of the bi-coxo-femoral axis. It corresponds to the sum of the sacral slope and the pelvic version.
The incidence manages the amount of lordosis for each pelvic tilt by the value of the sacral slope (Fig 2.58).

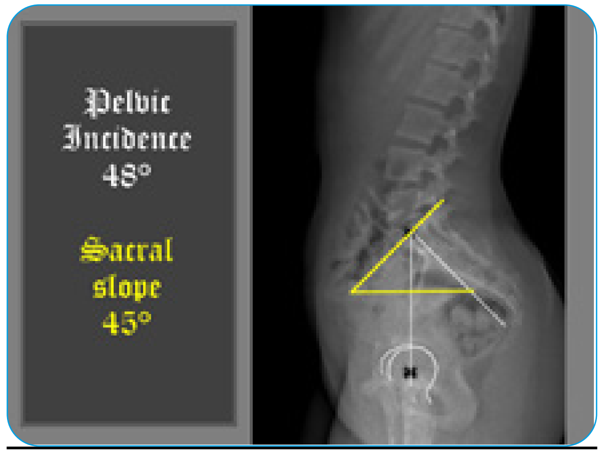



Fig 2.5 Lumbopelvic incidence

## Incidence (Statistics)

This is the frequency or probability of occurrence of an event in a population per unit of time, for example per year (see frequency and prevalence).

## Junction (zone)

This is the area or intervertebral space corre-

the value of pelvic version, lordosis and thoracic kyphosis.
Measuring lordosis and kyphosis is a first step, which must be completed by comparing them with theoretical values based on pelvic incidence. Associated with scoliosis, in half of all cases, adolescents show a decrease in curves in the sagittal plane and adults a decrease in lumbar lordosis with retroversion and an increase in thoracic kyphosis.

### Lyon Method treatment of isostatic imbalance

The first step in physiotherapy correction is to restore sagittal isostatic balance from bottom to top, starting with the pelvic version. ARTbrace integrates this correction during the 3 scans.

### From convexity to concavity detorsion

#### *The facts*

Convexity derotation is the basis of the 3-point system, with one pressure at convexity and 2 counter-pressures on either side at concavity. The disadvantage is that it favors a flat back at thoracic level.

Concave derotation was the basis of Schroth method directional breathing but was also used at the origin of the Lyon Method, the word «pneumatic» being coupled with the word «orthopedic» in the name of the Pravaz Institute. This internal shaping was very useful at a time when diaphragmatic poliomyelitis was frequently the cause of scoliosis. Concave derotation can complement overall mechanical derotation.

#### *Practicing the Lyon Method*

All lying position exercises are performed with a concave chondro-costal cushion. The ART-brace is in single contact at the convexity level in the upright position. Pressure is applied to the front concavity at the chondro-costal level under the chest, with a concave expansion to the rear to promote isostatic balance in kyphosis. This concave derotation takes place mainly in the seated position and lying down at night.

### From plane to solid geometry

#### *Definitions*

Plane geometry takes the form of tracing figures on a plane support, such as a sheet of paper or an X-ray. The first figures in plane geometry are the point, the straight line, the curve, and the circle. In scoliosis, tools such as ruler, level and protractor are used independently in the 3 planes of space. The frontal plane is the most commonly used. The Cobb angle, the «gold standard» of frontal radiography to this day, is in fact only the shadow of the scoliotic deformity. The most common geometric transformations in the plane are translations, central or axial symmetries and rotations.

In space geometry, a solid is generally defined as the set of points located inside a closed part of space. The solid has a thickness (a height, a length and a depth).
Since scoliosis is a three-dimensional circled helicoid deformity with a horizontal generating circle, it's more interesting to use solid geometry data, especially as today's scanners can restore volumes in a matter of seconds. These volumes can be read in 3D from Windows 10 (.stl files).

### Vocabulary evolution

The vocabulary changes with the volumetric concept. Today, horizontal derotation is replaced by detorsion. Axial self-elongation becomes geometrical detorsion.
The concept of mechanical detorsion is linked to coupled movements of the spine. The combination of sagittal isostatic balance, frontal correction by flexion or displacement, and the «mayonnaise tube effect» of bringing the vertebral bodies closer to the vertebral axis automatically generates mechanical detorsion.





*Chapter 3*

# 3. From anatomy to biomechanics

**«It seems likely to us that an excessive number of inclined vertebrae or excessive inclination may be sufficient, even from a small physiological scoliosis, for the development of severe progressive scoliosis.»**

**Vercauteren**

## ANATOMICAL BASIS

The scoliotic deformity is a three-dimensional curve that combines lateral curvature in the frontal plane with vertebral rotation in the horizontal plane and altered curvatures in the sagittal plane. We will first review the growth of the vertebral body, then describe the anatomo-pathological lesions and the mechanical factors involved in the initiation and progression of the deformity. Problems of frontal balance and posture will be addressed in Chapter 4. Experiments relating to the induction of scoliotic disease will be discussed in Chapter 5.

## Spinal growth

The spine develops according to 2 programs: a morphological program and a bone growth and adaptation program.

### *EMBRYOLOGICAL BACKGROUND*

Perichordal mesenchyme transforms into vertebral skeleton via somites. There are as many somites as there are vertebrae. Somites have a double destiny;
- by myotomes, they form the paravertebral musculature;
- by sclerotomes, they form the vertebrae.

Muscles and bones, as well as excretory and sexual organs, blood and blood vessels, all originate from the mesoderm. The endoderm forms the digestive tract, glands and lungs. The ectoderm forms the epidermis, nervous system, and sensory organs.
Spinal segmentation heralds functional unity.

In the sagittal plane, each vertebra is formed by the union of the lower half of one sclerotome and the upper half of the next sclerotome. In the anterior part, there is a space that will form the future intervertebral disc. The chorda is strangled by the proliferation of sclerotomes and remains at the nucleus pulposus level.

### VERTEBRA GROWTH

Ossification points appear in the pre-osseous cartilage. Ossification of the vertebral body is independent of that of the posterior arch. Towards the end of the second month, two ossification points appear in the posterior arch and fuse on the midline, closing the neural arch. The main ossification point of the vertebral body appears in the 3rd month. From birth to age 6, two bipolar cartilaginous zones persist between the vertebral body and the posterior arch. Asymmetry between these two growth zones on the right and left can condition the asymmetric collapse of the posterior wall seen in progressive scoliosis (Fig 3.1).

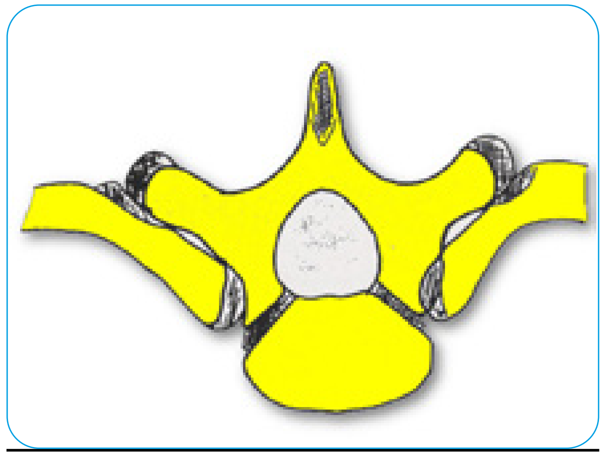


Fig 3.1 Growing vertebra

Around the age of 14, 5 secondary ossification points appear. 3 epiphyseal nuclei at the level of the spinous process and the 2 transverse processes; 2 annular marginal listels at the level of the 2 vertebral plates. The anterior common vertebral ligament partially inserts its fibers. At the end of growth, it is fused to the vertebral body. The vertical growth of the vertebral body is enchondral, similar to the vertical growth of long bones.

The posterior face or posterior wall of the vertebral body remains fixed during growth, and it is the growth of the posterior arch that determines the dimensions of the spinal canal. It is at the posterior wall level that the instantaneous kinematic rotation centers are concentrated, and that the characteristic scoliotic vertebral body deformity with partial asymmetric posterior wall collapse is formed.

## Growth regulation

**GENERAL FACTORS**

- Genetic factors and disturbances in chondrogenesis affect spinal growth, but in chondrodysplasia, kyphosis is more common than scoliosis.
- Endocrine factors: thyroid hormones, growth hormones, sex hormones, but scoliosis is rarely observed in these pathologies.
- The nutritional factor: rickets acts on the vascularized calcified cartilage layer, while vitamin D acts on the ossification zone. We'll look at the likely role of rickets in infantile scoliosis.

Gender has a definite influence on the rate of bone maturation.

**LOCAL FACTORS**

- The intrinsic factors linked to each bone are the growth plate and the periosteum.
- Extrinsic factors are mechanical, via the muscles according to Delpech's and Wolff's laws, which we'll explain later. Muscle damage will affect the growth of the vertebral body.

# VERTEBRAL GROWTH AND SCOLIOSIS

Idiopathic scoliosis is certainly linked to the phenomenon of vertebral growth, although the final size of the scoliosis does not differ from the average size of a non-scholastic population. Diméglio has clearly defined the course of pubertal growth, with an ascending phase from age 11, corresponding to the appearance of the thumb sesamoid, to age 13 in girls, corresponding to the fusion of the nuclei at the elbow. The Risser is always at O. The descending phase runs from age 13 to 15, from Risser 1 to Risser 5.

The development of the different segments of the vertebra depends on distinct ossification points: those of the anterior half and those of the posterior half, those of the right half and those of the left half. Asymmetrical vertebral growth can lead to a vicious circle of worsening scoliosis. The main aim of the brace is to guide the growth of the vertebral body and prevent the vicious circle from continuing.





## Anatomopathology

Hippocrates and Paul d'Egine (650) predicted the morphology of scoliosis, and Ambroise Paré (1550) described it for the first time. Since then, numerous studies have clarified the anatomo-pathological lesions;

Before 1950; Wolff, Delpech, Sayre, Lovett, Putti, Abbott, Albee, Lance ;
After 1950; Ponseti, Ferguson, Cobb, Moe, Metha, James, Riseborough, Perdriolle.

## SCOLIOTIC DEFORMITY

Scoliosis occurs in all three planes of space. We need to distinguish between 2 reference points: one absolute in relation to the pelvis or line of gravity, the other relative, one vertebra in relation to the other. The paradox is that, at a segment level, an absolute clinical kyphosis may in fact correspond to a relative extension of the vertebrae in relation to each other, i.e. a relative lordosis. This is the case of rotatory kyphosis.

### *IN THE FRONTAL PLANE*

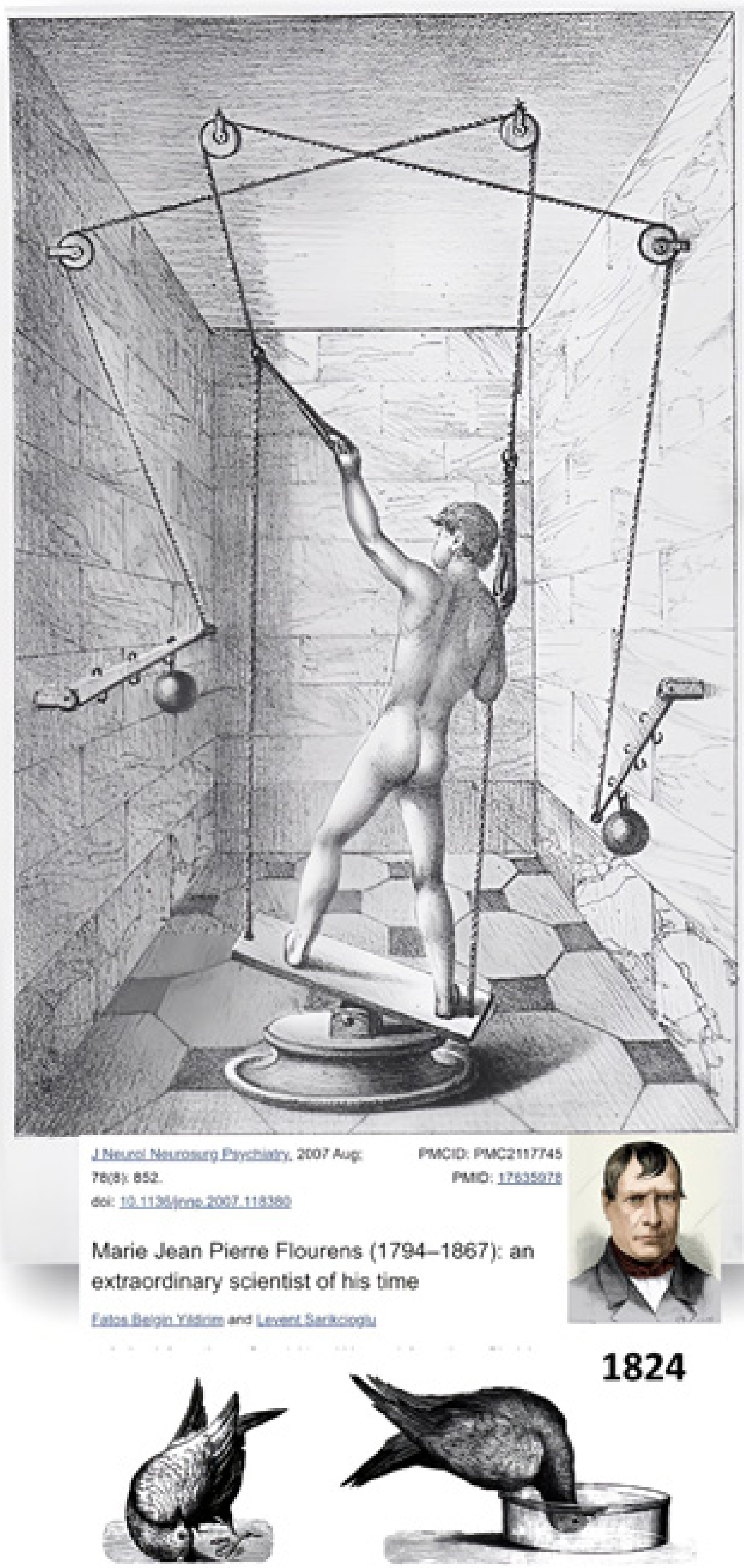
Lateral inflection is a lateral curve that causes a number of the vertebrae to move away from the midline. It is clinically expressed by a change in the line of the spinous processes. It is characterized by an apex, the vertebrae at the apex being furthest from the median axis, and by limiting or neutral vertebrae at the ends of the curve, where the intervertebral joints become horizontal again.
The extent of the curve isolates total or partial curvatures. The number of curves isolates single or double curves, in which case a distinction is made between main or compensatory curves (Fig 3.2).

Fig 3.2 Evolution of scoliosis

The location of the deformity allows us to describe different types of localization. All these elements enable us to classify the different types of scoliosis, and to measure the angulation and spontaneous reducibility of the curves (suspension, flexion). The posterior arch turns towards the concavity, but to a lesser extent, as it is restrained by the articular masses and the musculo-ligamentous apparatus. The result is a veritable distortion between the vertebral body and the posterior arch. The vertebra's anteroposterior axis no longer passes through the middle of the vertebral body, the middle of the spinal canal and the spinous process. There is an angle between the axis of the vertebral body and the axis of the posterior arch, which tends to close on the side of the scoliotic concavity during evolution.
In the horizontal plane, scoliotic rotation or torsion concerns the vertebra and the entire curve and is directed towards the convexity of the curve.

### *ROTATION OF THE ENTIRE CURVE*

At the same time as the lateral tilt is established, the spine rotates around a fictitious axis that lies behind the posterior wall of the vertebral body. The vertebral body rotates towards the convexity of the curve; the posterior arch rotates towards the concavity, but more moderately and according to the different arrangement of the articular processes at the thoracic and lumbar levels. In the lumbar region, rotation is often very significant. Overall rotation of the curve determines costal




*Off-text illustration: After the first experiment with the scoliotic pigeon after destruction of the labyrinth, Pravaz introduced stimulation of the postural system in the corrected position. This is the orthopedic swing.*





*Chapter 4*

# 4. From balance to posture

**«Only statues are immobile. Standing, at rest, man is never immobile, but constantly oscillates according to particular and complex rhythms that account for the functioning of the different sensory-motor loops that place and maintain the center of gravity in the polygon of sustentation.»**

**Jean Bernard BARON**

## PHYLOGENETIC REMINDER

Bipedalism is a fundamental phenomenon in the phylogenetic evolution of hominids. It is characterized by a number of structural modifications designed to maintain the line of gravity within the support polygon.

The development of the cranial cavity by reducing bone structures and increasing the foramina-facial angle enables the development of associative zones.
Regression of the facial mass allows the skull's center of gravity to shift back towards the condyles. This modification results in a better distribution of the moment forces that manage the inter-support balance lever controlling the position of the head on the cervical spine. This further includes:

- Changing body proportions,
- Preservation of the hand's pentadactyl structure,
- Modification of spinal curves,
- Elevation of the center of gravity, which is projected forward of S2, and
- Halving the ground support surface.

Changing the pelvis and limb bones are the main developments (Fig 4.1).

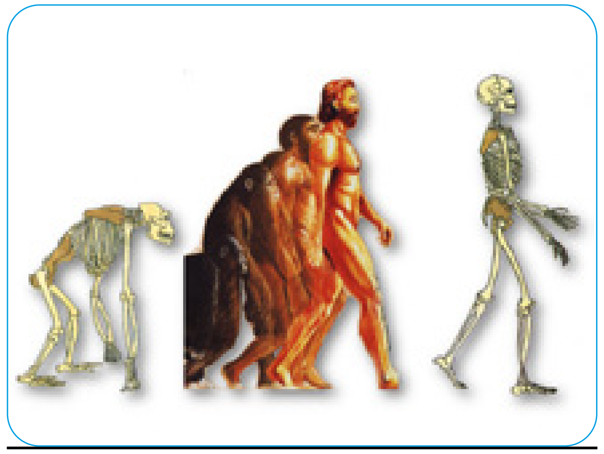


Fig 4.1 Phylogenesis of homo sapiens

Postural tonic activity is regulated by complex neuromuscular mechanisms involving a hierarchical temporo-spatial organization based on numerous sensory-motor loops. It contributes to placing the center of gravity within the support polygon with a minimum of energy. It is a physiological constant of the human species, with its own rhythm, just like the cardiac and respiratory rhythms (1).

## DEFINITIONS

- **Endosensors;** structures providing information on the relative positions of body segments.

- **Balance**: all the mechanisms that help maintain posture despite the causes that tend to disturb it in the standing position; static balance, and when walking or moving; dynamic balance.

- **Exosensors**: structures providing information linked to the outside world.

- **Posture**: fundamental attitude of a species, erect station in man.

- **Tonus**: permanent muscular contraction that fixes the mutual position of skeletal parts without being accompanied by movement.

## PHYSIOLOGICAL REMINDER

Posturology is the study of the fine regulation of vertical position. For spinal deviations, the physiological principle is based on the transition from a voluntary pyramidal muscular correction of the deviation to an involuntary extrapyramidal correction facilitated by exercises. Pyramidal cortical representation is very weak at trunk level and is mainly used for learning corrective positions (Fig 4.2).


Fig 4.2 Weak voluntary cortical representation of the spine

Exosensors include the insoles, the eye and the vestibule. The endo-sensors are all the proprioceptors of the body's axis. The postural system integrates multiple afferents by making choices or tactics, and multiple compensations are possible. There is no scoliosis in children with congenital blindness.
It is the repetition of corrective gestures, involving as many sensors as possible, that enables the automation of corrective alignment and postural integration (Fig 4.3).

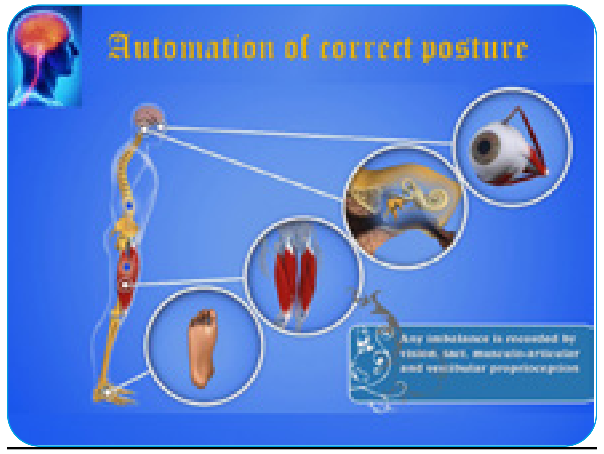



Fig 4.3 Extrapyramidal function

This integration is both static and dynamic. Alignment is managed by static sensors in the muscles, fascia, and tendons, as well as in the joints. Posture is managed by dynamic sensors (Fig 4.4).

(1) 1 We have drawn on Jean François Favre's doctoral thesis entitled << Participation of postural tonic activity in the genesis of certain scoliotic attitudes. Application à la compréhension de certaines contre-performances gestuelles de l'athlète et à leur éventuelle correction >>.





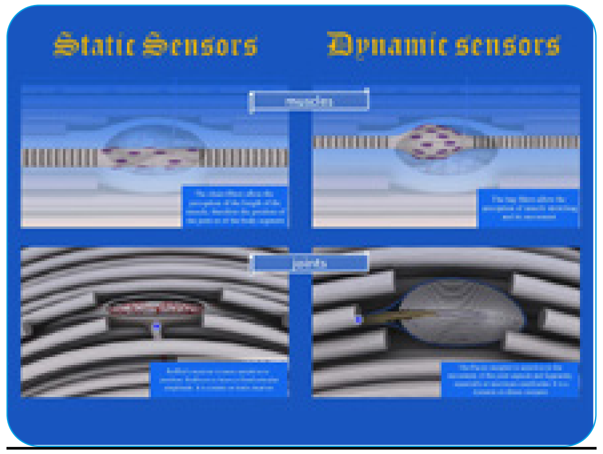



Fig 4.4 Static and dynamic sensors

The extrapyramidal system comprises 4 specialized pathways. The first is the reticulospinal tract, which specializes in muscle tone against gravity. This is the pathway of upright posture. Sensorimotor coupling takes place at the level of the reticular formation of the brainstem (Fig 4.5).

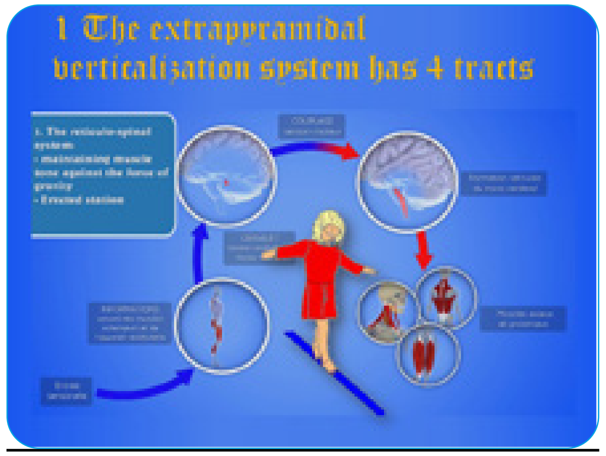



Fig 4.5 Reticulospinal tract

The second is the vestibulospinal tract, which involves the vestibular balance system. This tract controls static adaptation, e.g. feet on a tilting platform. The consequence is the search for head balance despite postural correction (Fig 4.6).

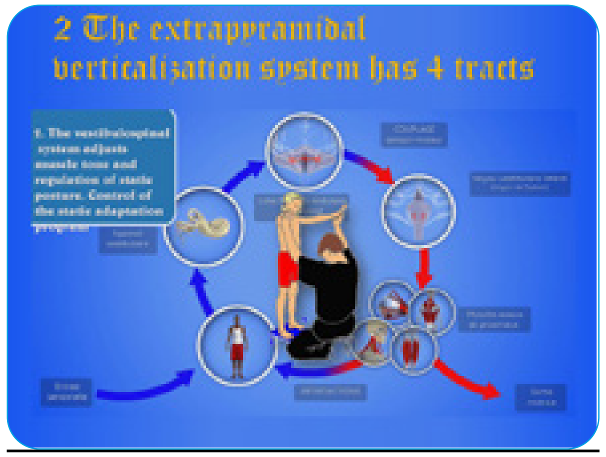



Fig 4.6 Vestibulospinal tract

The third is the rubrospinal tract, which controls dynamic posture after a major imbalance to prevent falling. It is used in Swiss ball exercises. Sensorimotor coupling also involves the vestibule and the red nuclei of the reticular formation (Fig. 4.7).

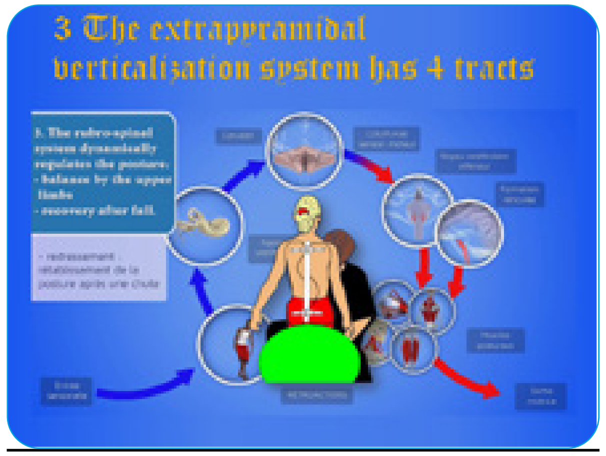
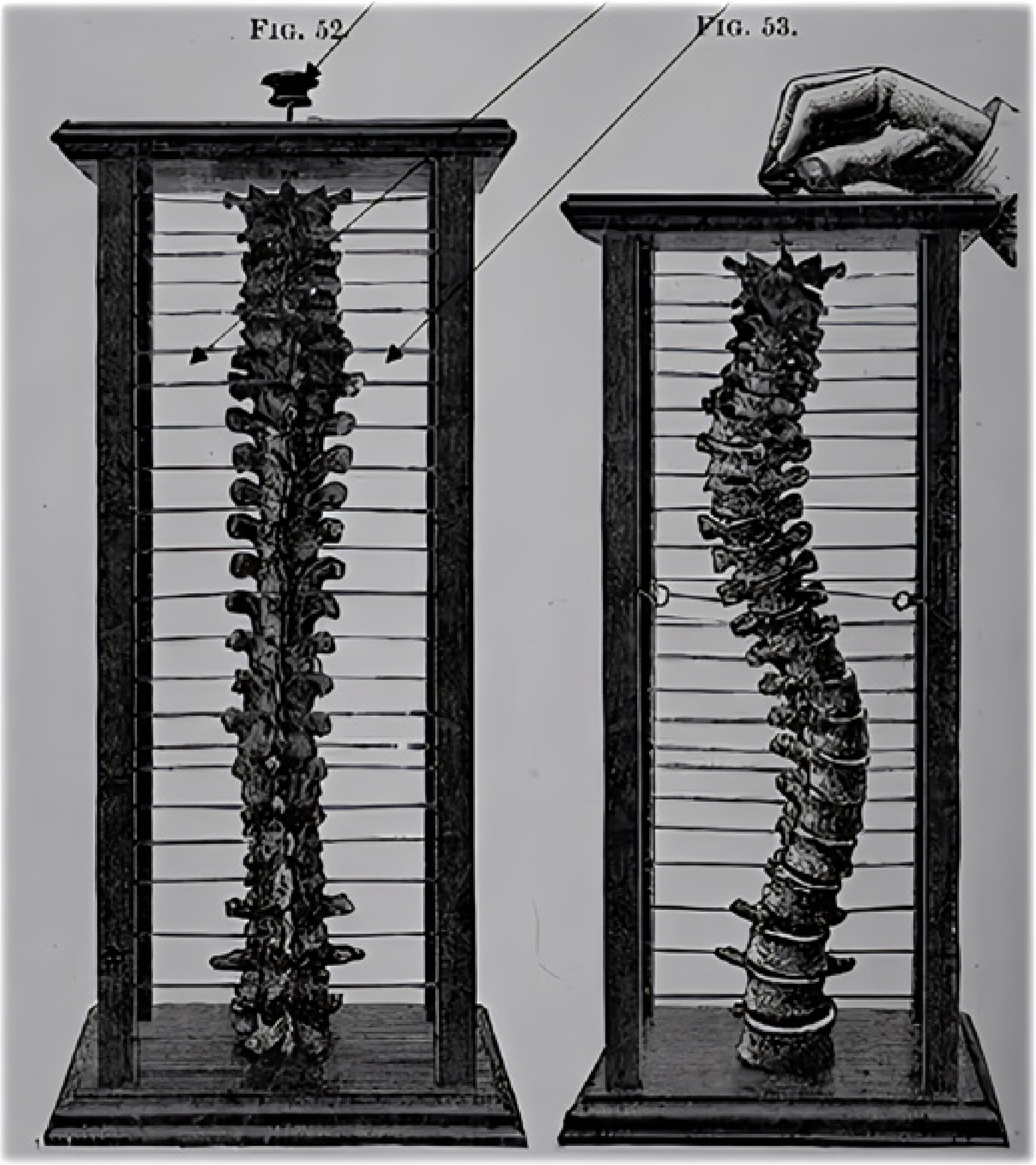



Fig 4.7 Rubrospinal tract

The fourth tract is the tectospinal tract, specific to the cervical spine and eyes. Sensory input occurs almost exclusively at the level of the semicircular canals. Coupling involves the oculo-motor nuclei, as effector muscles are located at eye, cervical spine and upper limb levels (Fig 4.8).




*Off-text illustration: A flexible copper rod inserted into the spinal canal holds the vertebrae in place. The spinous processes are attached to the vertical rods by a rubber band in the horizontal plane. Pressing the button creates structural scoliosis, and pulling the button creates a straight spine.*
*Lewis Sayre's experiment 40 years after the publication of Pravaz's book confirms the buckling effect and, above all, the correction by axial elongation.*





*Chapter 5*

# 5. From experiment to natural history

**«It's distressing to think that such a significant impairment can appear in an otherwise healthy child, and we still don't know the cause. We can't say, in fact, whether the cause is muscular, bony or biochemical.»**

**JIP James**

## Experiment

A great deal of work has been done on the initiation of scoliosis processes, but almost all of it also focuses on normal development and anatomy. Several types of experiment reproduce scoliotic deformity, but none of them provide any indication of the primary changes initiating the disease.

These experiments are of three types;
1. The first concerns the growth of bones, muscles and ligaments;
2. The second concerns metabolic and chemical factors;
3. The latter concern the central nervous system, the vestibule and balance or peripheral nerves.

## Surgical procedures on bones, muscles and ligaments

### ON GROWING BONE

A great deal of research into experimental scoliosis focuses on the mechanical forces that cause abnormal growth of the spine through unilateral disruption of applied forces, or by slowing growth on one side of the vertebra.

### *PRESSURE ON THE EPIPHYSES*

Hueter claimed that a continuous, unilateral load on the vertebral epiphyses reduces the growth potential of the vertebral body, which then becomes trapezoidal. The result is a concave lateral inflection on the compressed side, but no rotation.

### *SPINAL STAPLING*

Similar effects have been obtained by stapling several vertebral bodies (Haas) or by unilateral surgical destruction of the epiphyses. Haas and Bisgard produce scoliosis in a wide variety of animals (rabbits, dogs, pigs), but the deformity is not comparable to that in humans, as there is no rotation or progressive worsening.

## COSTAL LIGATURES

Langesnkiold and Michelsson (1965) produce scoliosis of over 90° in growing animals, by unilateral ligation of the ribs and transverse processes. Severe scoliosis (greater than 125°) can be obtained by resection of the posterior part of the ribs and excision of part of the vertebrae (lamina and pedicles).

## CHANGES IN TWO PLANES OF SPACE

Lawton and Dickson (1986), create in rabbits after laminectomy:
- pure thoracic lordosis,
- or a pure scoliotic inflection,
- or a lordosis and scoliotic inflection.

In the first two cases, there is no three-dimensional scoliosis; it only appears in the third case, and when the lordotic component has been removed, the scoliosis improves. It therefore seems necessary to accumulate anomalies in two planes of space to create a three-dimensional deformity.

## COSTO-TRANSVERSE JOINT

Pal (1989), studied the role of force transmission to the vertebral body via the ribs, the costo-transverse joint and the lamina. In 20 adult rabbits, he resected either the transverse process or the facet joint, or both. Scoliosis developed most rapidly in the latter cases. The convexity is on the operated side, and the apex is below the operative zone. He concludes that asymmetric force transmission with vertebral instability is the cause of scoliosis.

## ON MUSCLES AND LIGAMENTS

Sectioning the costovertebral ligaments or the internal and external intercostal muscles causes scoliosis in the animal, the severity of which depends on the extent of the surgery. As soon as the deformity is present, structural disorders of the vertebrae can be observed. Unilateral sectioning of the trapezius, latissimus dorsi, sacrospinatus, iliopsoas, intercostal and abdominal muscles, on the other hand, produces only a slight scoliotic curve. Weaning the muscles and ligaments of the thoracolumbar junction produces a kyphosis, which is accompanied by lateral inflection when the interspinous and yellow ligaments are removed.

On the occasion of operative muscle biopsies, Lokietek noted 4 unique findings:
1. The scoliotic phenomenon is not due to an enzyme deficiency or intrinsic congenital muscle defect. It results in different muscle performance on the convex and concave sides.
2. Muscle hypotrophy is more pronounced on the concave side, reflecting the shortened position of the concave muscle.
3. Convex muscles have better enzymatic machinery, but this does not allow us to prejudge their contractile capacities. Increased oxidative activity reflects better maturation conditions.
4. The reduction in IIb fibers on the convex side suggests a muscle tissue reorganization mechanism.

These data mainly reflect the consequences of immobilization and deformation.

**Experiments in functional electrical stimulation**

Schultz had shown that after 5 weeks of flexion immobilization, rats developed scoliosis. Bobechko reproduced the experiment by stimulating the pig's paravertebral muscles with a pacemaker. After 8 weeks of stimulation, two-thirds of the animals developed structural scoliosis, proving that scoliosis can be induced by stimulation of the paravertebral muscles (Fig 5.1).






Fig. 5.1 Scoliosis induced by an asymmetrical brace

Eight weeks after stopping the stimulation, the curves remained stable. Discontinuous stimulation did not result in muscle mass imbalance or histological changes in the fibers.

Monticelli (1975) stimulated rabbits in 3 batches, for 45, 90 or 120 days. Spinal curvature appeared after 18 days. After 45 days, an average curve of 20° was obtained, which regressed to 6° thirty days after stimulation. 90 or 120 days of stimulation give comparable results, with a curve of 30° persisting at 25° after 30 days of rest. This is a true structural scoliosis with rotation and lordosis.

Olsen (1977), stimulated the paravertebral muscles of 24 dogs aged 3 to 5 months. The magnitude of the curve increased with increasing tension. With adapted parameters, the dogs showed no discomfort. Stimulation to the right resulted in a curve to the left. After 4 weeks of treatment, the curve was structural and remained stable after stimulation stopped, whereas before 4 weeks, there was a regression. Prolonged stimulation beyond 4 weeks did not alter the curve due to antagonist resistance. One of the dogs was then stimulated on the opposite side, with regression of the initially induced scoliosis and formation of an opposite curve.

Ahran and Rigault (1981) studied the parameters of electrical stimulation as a function of contraction force and fatigability. Muscle strength increases with the intensity of stimulation. The longer the static work imposed on the muscle, the longer the recovery time between two stimulations.

Schultz (1981) studied the effects of muscle contraction on a biomechanical model of 68 muscles and 13 scoliosis configurations. Contraction of the convexity muscles corrects the curve. To achieve maximum contraction, muscles with a large cross-sectional area or positioned laterally should be selected. Most muscles are strong, and a low-intensity contraction will affect the curve. Standing lumbar curves should not be corrected by stimulation, due to the postural reflexes of the trunk. The correction of a curve is not affected by the existence of a counter-curve, nor initially by the extent of evolution. Action in the 3 planes of space is independent. To avoid the development of counter-curves, only effective muscles need to be stimulated.

## Experiments on the nervous system

**PERIPHERAL NERVOUS SYSTEM**

Motor nerve transection has the same effects as muscle excision. Cutting posterior sensory nerves in animals (Liska and Mac Ewen, 1973) causes scoliosis at a significant rate. The severity of scoliosis depends on the number of severed nerves. However, Alexander's experiment does not confirm this phenomenon and, on the other hand, section of the posterior nerves would lead to degeneration of the entire anterior horn.

For Lokietek, reduction of unilateral afferences by sensitive rhizotomy disrupts muscle maturation asymmetrically; carried out at different times during growth in animals, it leads to progressive curves whose rate is comparable to that of human scoliosis.

Suk (1989) performed posterior, anterior and mixed rhizotomies on 4 groups of rabbits, with the fourth group undergoing laminectomy only as a control group.
There was no significant difference in scoliosis angulation between the three rhizotomy groups. Scoliosis progression was longer in the posterior rhizotomy group. Muscle denervation is negligible in the latter group, so scolio-

## Conclusion

***There are many types of scoliosis in adults. Brittle bones, disc degeneration, joint osteoarthritis and musculo-ligamentousstructures can cause scoliosis to evolve and even degenerate. As in children, we believe that this evolution obeys the chaos theory and remains unpredictable. It is therefore important to monitor these patients closely. We recommend a check-up every five years by a specialist, who alone can detect the small flaws that herald cataclysm.***

*Off-text illustration:The ultimate evolution of scoliosis in old age is **camptocormia**. When the patient is motivated, it is often possible to realign the spine with the line of gravity using an ARTbrace combined with the Lyon Method of physiotherapy.*





*Chapter 6*

# 6. From clinic to assessment

**"It's the gaze of a child with a deviated spine that the physiotherapist is confronted with, even if it's the child's back that's the problem. This gaze expresses all states of mind: anxiety, fear, pain, joy, indifference, opposition, aggression, disappointment, anger, confidence, complicity. Restoring that calm, confident look is the aim of these long talks, which are a prelude to the treatment of any spinal condition."**

**Yves JARROUSSE**

## Simplified assessment: school screening

### DEFINITIONS

#### *SCREENING:*

Presumption of an unknown disease through rapid tests or control examinations. Screening is not a diagnosis, but a referral to a specialist. When a child is selected, screening is said to be positive; when a child is eliminated, screening is said to be negative. The value of screening lies in the relationship between selection and pathology.

POSITIVE TRUE; Screening of a child with true scoliosis.
FALSE POSITIVE; Detection of a child without scoliosis.
TRUE NEGATIVE; Eliminate a child without scoliosis.
FALSE NEGATIVE; Eliminate a child with true scoliosis.

**SENSITIVITY**: Sensitivity is defined by the rate of true positives (true positives + false negatives). A test is considered highly sensitive when all scoliosis is identified and there are no false negatives, i.e. when true scoliosis is detected and all scoliosis is detected without falling through the cracks.

**SPECIFICITY**: This is defined by the rate of true negatives (true negatives + false positives). The high specificity of a test is defined as the elimination of all non-scoliotic children and the absence of false positives, i.e. the elimination of all children without scoliosis.

**OBJECTIVES**
Screening enables early orthopedic management, thus avoiding surgery. In scoliosis, there's no going back, and it's better to stabilize at 25° than at 40°.
Thanks to the epidemiological data com-

pendium, a better understanding of natural history is possible.

### SCREENING CONDITIONS

The test must be simple for the examiner, effective for the doctor, and inexpensive for society. It must be applied at the right time, i.e. during the pubertal period, i.e. 11-13 years for girls and 13-15 years for boys. The local health structure must allow for early treatment.

### SCREENING TECHNIQUES

**ANTERIOR TRUNK FLEXION TEST (ADAMS)**

This test shows a hump or inflection of the trunk, generally with a large radius. Clinically, it is performed with the feet together and the big toes close together, without rotation. The hands are clasped and project between the knees to prevent rotation of the scapular girdle. Trunk flexion of around 60° is required for a thoracic curve, and 90° for a lumbar curve (Fig. 6.1).

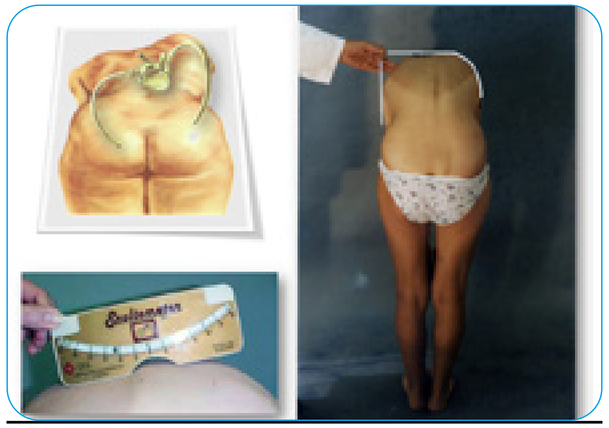


Fig 6.1 Adams test: hump measurement

A "scoliometer" can be used to calculate the asymmetry of the thoracic rotation angle in relation to the horizontal.
This test is questionable for small angulations because of several factors, such as:
- an imbalance of the pelvis causes a lumbar hump, even without scoliosis. In this case, the inequality must be assessed clinically, for example at the level of the iliac crests, and the hump must be checked for disappearance with a compensating heel pad.
- asymmetric tension of the paravertebral ligaments may cause protrusion, although there is no deviation on a standing X-ray.
- there is no correlation between radiological angulation and hump (UPADHYAY, 1988).

The screening zone is 5 to 10 mm for the hump and 3 to 7° for the thoracic rotation angle.

***TEST VALIDATION***

We're going to choose the classic test to measure hump.
- For an identical observer who performs the test several times, the standard deviation is 3 mm.
- Between several observers examining the same child, the standard deviation is 3.7 mm.

### *Clinical elements of screening*

1. Shoulder imbalance
2. Protrusion of a scapula
3. Visible spinal curve
4. Iliac crest imbalance
5. Asymmetry of the waist crease or dormer sign (Fig 6.2).

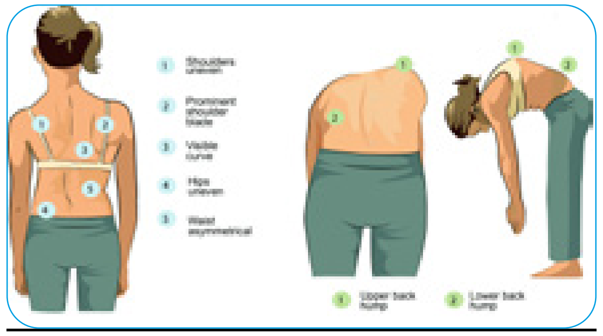


Fig 6.2 Clinical elements of screening

**RESULTS OF MAJOR ANGLO-SAXON SURVEYS**

- Screening personnel must be trained, but there is no significant difference between doctors and non-physicians (Ashworth, 1988).
- Systematic screening does not significantly alter the average angulation at which scoliosis is discovered.
- Systematic screening does not significantly modify the number of children operated on between regions with and without screening, or within the same region over the last 30 years. (Goldberg, 1995).
- This rate is 0.045%, or around 300 cases per year in France.
- The economic results are negative, with a considerable number of false positives, i.e. the detection of small deviations that will not evolve. These cases require costly additional tests. Early orthopedic treatment is costly and requires the active participation of the family and the child. The cost of screening to select 2/1000 of the school population is therefore too high.





**THE FRENCH EXPERIENCE**

Having learned from the failure of screening as described above, we turned our attention to a more global approach to spinal column management. In collaboration with the Association pour le Développement et l'Education à la Santé de l'Isère, the Ecole du Dos de Lyon set up "classes du dos" to raise awareness of back problems among children and teachers. How to carry a schoolbag? Spinal economy, sitting posture and specific gymnastic movements are discussed in small groups (Fig 6.3).

Fig 6.3 Back school for scoliosis

## Complete orthopedic medical check-up

### THE GOALS

Four objectives are essential;
- orthopedic assessment of the deformity ;
- determining the child's stage of growth to determine the risk of evolution;
- exploration of the etiological context: scoliosis is a symptom before it is a disease;
- psycho-family assessment.

### FAMILY DATA

The mother's date of birth can have an impact on the frequency of scoliosis, divorced parents can make treatment more difficult, and siblings should also be examined.

### HISTORY

The first thing to do when a patient with scoliosis comes for a check-up, or has been prescribed physiotherapy, is to get to know them, to take a history not only of their scoliosis, but also of everything important that has happened in the health field up to now. Reading the patient's health record is essential.

### FAMILY HISTORY OF SCOLIOSIS

A family history of scoliosis is found in 25% of cases. The patient is asked about any treatment, its results, current status and degree of satisfaction.

### MEDICAL HISTORY

In order to find an etiology, we ask the patient to specify at least the age of walking, possibly the age of maturation in boys and of the first menstruation in girls, the existence of rapid growth in progress, the shoe size, the sport practiced, specifying the number of hours per week, the ranking in gymnastics classes, the existence of breathlessness...


*Off-text illustration: The ARTbrace is a detorsion brace developed in Lyon using the EOS 3D System. Thanks to this system, we were able to demonstrate coupled movements during the fitting of the brace.*





*Chapter 7*

# 7. From radiology to imaging

**«X-rays are fundamental documents for identifying spinal deformities. There are two risks; too much or too little.»**

**P. STAGNARA**

## Standard radiological examination

The vast majority of scoliosis, especially idiopathic scoliosis, are simply explored by full-face and full-profile views (from the scapular girdle to the femoral heads) in the upright position during the initial workup, followed by repeated full-face views to monitor treatment and progress. The purpose of imaging is:
- to confirm scoliosis;
- try to link this scoliosis to a specific etiology;
- provide elements for therapeutic discussion according to etiology and evolution;
- to take part in surveillance.

The high level of radiation delivered by all these images means that their indications must be kept to a strict minimum. However, the EOS system reduces radiation levels and should gradually become the standard. Modern imaging (scan, MRI) is only indicated in very specific cases (symptomatic scoliosis, neurological signs, preoperative assessment, etc.).

The patient's back is in contact with the X-ray plate. In contrast to chest X-rays, in order to more easily superimpose clinical and radiological examinations, it is advantageous to examine films "from behind", with the right side of the film to the observer's right.

### INITIAL RADIOGRAPHIC EXAMINATION

During the initial work-up, two X-rays of the entire spine are taken: frontal and lateral upright views. The prone frontal X-ray was mainly used in the poliomyelitis era.

### X-RAY CONFIGURATION

All these films take the whole spine, with top/bottom superimposition if necessary, depending on the child's size. The final film is generally reduced to 50%, which facilitates certain numerical calculations.
Digitization will help reduce contrast differences between thoracic and lumbar segments.

### *STANDING FRONTAL RADIOGRAPH*

The subject is placed in a strictly frontal position, standing barefoot, back against the plate, with a lead shield protecting the gonads. In girls, the shot can be taken with the abdomen in contact with the plate, thus reducing irradiation of the breasts and gonads, whose protection by a lead shield is much more uncertain than in boys. The visualized area should cover the body from the lower jaw to the subtrochanteric region (Fig. 7.1).

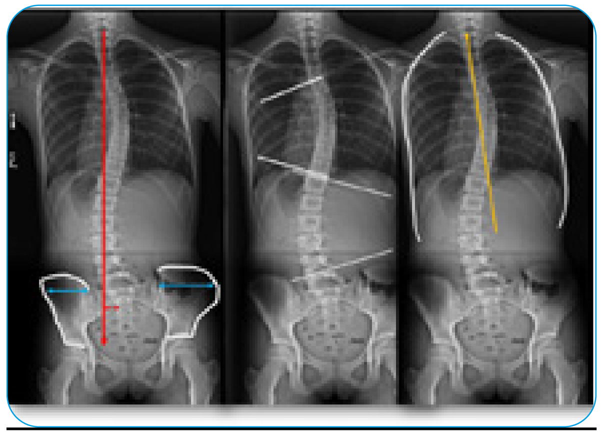


Fig 7.1 Frontal radiographs

## STANDING LATERAL RADIOGRAPH

The subject is positioned strictly in profile, standing with bare feet. Protection of the breasts and gonads is not possible. He holds his hands forward, resting on a support, elbows slightly bent, so as to clear the spine without modifying the sagittal curves. The image should show the base of the skull at the level of the femoral heads.

**INTERPRETATION**

The first step is to look for morphological abnormalities, in particular vertebral deformities, which may lead to additional imaging focusing on the lesions. The second step is to assess vertebral curves.

***FRONT VIEW STANDING***

It is used to assess the curve(s) in the frontal plane. A curve is defined by its side and its amplitude. The side of the curve is the side of convexity. The amplitude of the curve is assessed using the Cobb method. To do this, it is necessary to determine:

- the apical vertebrae at the apex, i.e. the vertebra in the middle of the curve with the minimum inclination to the horizontal and maximum rotation, if any;
- the upper and lower limiting vertebrae, which are the vertebrae at either end of the curve with the greatest inclination to the horizontal. The amplitude of the curve is defined by the value in degrees of the angle formed, in the concavity of the curve, between the upper plateau of the upper limiting vertebrae and the lower plateau of the lower limiting vertebrae.

For control purposes, all subsequent measurements must be taken from the same limiting vertebrae to be truly comparable.

The curve may be thoracic, thoraco-lumbar or lumbar.

Depending on the location of the curve, there are four types of scoliosis (according to Ponseti).

TYPE 1; THORACIC SCOLIOSIS (25%)
- upper limit of vertebrae; T4, T5 or T6 ;
- lower limiting vertebrae; Tll or T12 ;
- apical vertebra; between T9 and Tll.

TYPE 2; THORACOLUMBAR SCOLIOSIS (19%)
- upper limit of vertebrae; T4, T5 or T6 ;
- lower limit of vertebrae; L1, L2 or L3 ;
- apical vertebra; T12 or Ll.

TYPE 3; LUMBAR SCOLIOSIS (25%)
- upper limit of vertebrae; Tll or T12 ;
- lower limiting vertebrae; L3 or L4 ;
- apical vertebra between Ll and L4.

TYPE 4; SCOLIOSIS WITH TWO MAJOR CURVES (30%).
- The two curves are generally dorsal and lumbar, or double-thoracic or thoracic and thoracolumbar. Cervicothoracic scoliosis is very rare (1%).

A major or principal curve is defined as the one with the greatest amplitude, rotation and hump, and on which vertebral trophic disorders are located. There may be a single major curve or two major curves (double major scoliosis) of equal amplitude. A minor or secondary curve is a curve adjacent to the major curve, non-reducible, of lesser amplitude, rotation and hump. A major curve is often accompanied by two superior and inferior curves. The amplitude of the major curve is generally close to the sum of the amplitude of the two secondary curves.

Vertebral body rotation is also assessed from the front view. Rotation is measured on vertebrae at the vertex level, where it is maximal. The vertebral body rotates towards the convexity and the posterior arch towards the concavity of the curve.





The degree of rotation can be assessed by two semi-quantitative methods:
- Cobb's method evaluates the displacement of the spinous process projection towards the concavity, which ranges from 0 to 4 + ;
- the Nash and Moe method measures the distance of the pedicle on the convex side from the lateral edge of the vertebra. The measurement is noted in rates.

We also use the Perdriolle and Vidal method on 1/1 without reduction. They have developed a torsiometer that allows us to obtain a direct value in degrees of vertebral rotation on the front view.

The torsiometer is superimposed on the vertebral body of the vertebra (usually the horizontal vertebra at the apex of the curve). The vertical line of the torsiometer that is tangent to the vertebral edge of the convexity is moved up and down so that the oblique line of the torsiometer is also tangent to the concave edge of the vertebral body.

For a thoracic vertebra, the concave point of tangency is located between the 2 vertebral plates. For a lumbar vertebra, the concave point of tangency is located at the level of the upper plate. The torsion figure is given by the oblique line passing through the long axis of the convexity pedicle.

The front view should also allow assessment of pelvis statics and overall spinal balance.

Normally, the tangent line passing through the lower part of the sacroiliac joints is horizontal. If this line is oblique, the pelvis is said to be oblique to the right or left. Inequality in the length of the lower limbs is measured in centimeters by measuring the difference in height at the top of the femoral heads.

The vertical line passing through the odontoid should normally pass through the middle of the sacrum. If this is not the case, the curve is said to be unbalanced to the right or left.

***PROFILE VIEW STANDING***

It allows sagittal curves to be assessed. Thoracic kyphosis is measured by the angle formed between the lower plateau of the most inclined transitional vertebra at the thoraco-lumbar hinge and the upper plateau of the first most inclined thoracic vertebra visible between T1 and T4.

Lumbar lordosis is measured by the angle formed between the upper plateau of the first sacral vertebra and the upper plateau of the transitional thoracolumbar vertebra (including the L5-S1 intervertebral disc).

Vertebral balance is assessed by the lowered vertical of the external auditory canals, which should normally pass through the center of the femoral heads (Fig 7.2.).

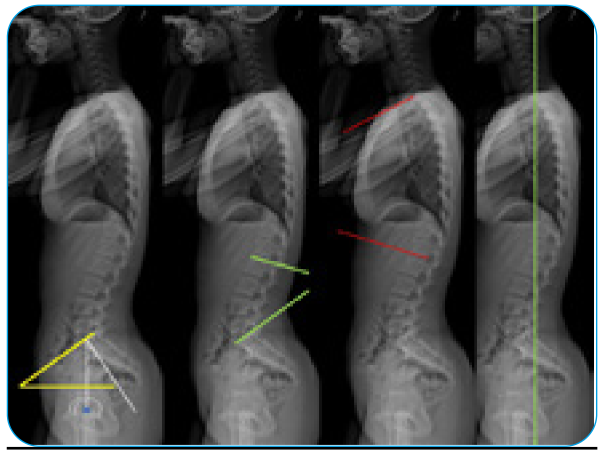


Fig 7.2 X-ray in the sagittal plane

## OTHER STANDARD RADIOGRAPHIC VIEWS

These are views in the plane of election and views of reducibility. They are sometimes necessary before surgery, but are not systematic.

***RADIOGRAPHY IN THE PLANE OF CHOICE OF THE CURVE***

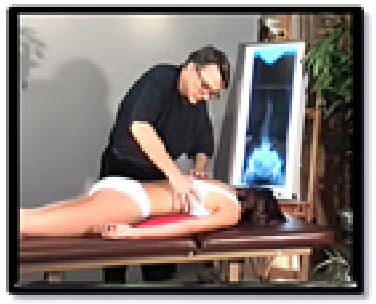
It is particularly useful for large deformities combining scoliosis and kyphosis, as a simple frontal view underestimates the extent of the curve. An oblique view provides a better "spread" of the deformity and its components. The patient should generally be positioned so that the medial side of the hump is parallel to the cassette.

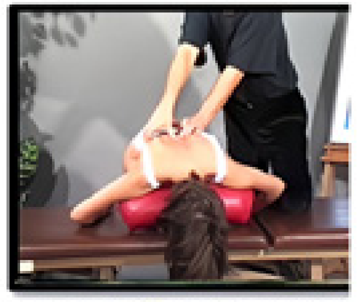
***REDUCIBILITY RADIOGRAPHS***

These films are of great importance in the indication and choice of treatment, particularly for preoperative purposes. They assess the reducibility of the main curve and compensatory curves. Bending radiographs are taken in the supine position, with maximum right and


1. Awareness of postural defects


2. Kyphotization of the thoracic region


3. Passive Mobilization


4. Mobilization of th rib-vertebral joints


5. Opening Ilio-lumbar angle


6. Active Mobilization


7. Lumbar Sagittal & Frontal Correction

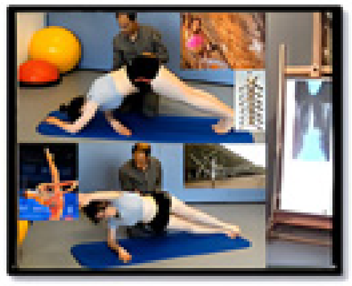

8. Thoracic Sagittal & Frontal correction


9. Grand Porter


10. Proprioceptive exercises

*Ballistic Stretching*


11. Balance exercises


12. Core stabilization

*Off-text illustration: The 12 basic exercises of the Lyon Method were published in 1978. Used for idiopathic scoliosis, they can be adapted whatever the etiology of the scoliosis.*





*Chapter 8*

# 8. From etiology to idiopathy

**"There is no such thing as one scoliosis; there are an infinite number of scoliosis. However, it is possible to establish broad categories of vertebral deviation."**

**L. OMBREDANNE**

## CLASSIFICATION OF ETIOLOGIES

### Neurogenic scoliosis

#### *CENTRAL MOTOR NEURON DAMAGE*

**CEREBRAL PALSY**

Involvement of the central motor neuron is generally very early, and the phenomena of spasticity, athetosis or rigidity disrupt the deficiencies of voluntary control. Scoliosis occurs during growth in 20% of children, mainly tetraplegics or spastic paraplegics, and often takes the form of a large cypho-scoliotic "C" curve. Paradoxically, infantile hemiplegia leads to much less progressive scoliosis. The mechanism is therefore more related to tonus disorders than to muscular weakness, and spasticity creates asymmetrical contractures and retractions.

Rotation is proportional to lateral inflection, but in the sagittal plane, this is a kypho-scoliosis. Half of all patients retain a lumbar lordosis, even in the sitting position. Most scoliotic patients have asymmetrical spasticity, with an oblique pelvis and hip dislocation (Fig 8.1).


Fig 8.1 Cerebral palsy

**Physiotherapy**

The indications for scoliosis physiotherapy in patients with cerebral palsy are very similar to those for paralytic scoliosis. However, indications will never be discussed in isolation from the spinal problem alone, but will form part of a general program of repair and physiotherapy.

Physiotherapy for associated scoliosis is based on the guiding principles of modern scoliosis therapy (neuromuscular facilitation methods). The extent of retractions and vicious attitudes, areas of spasticity and intellectual coefficient are all factors which determine indications and therapy. Orthopedic or surgical treatment of vertebral deviation often enables the patient to climb one or two steps, within the limits of his or her functional capabilities (lying down only, sitting, standing, walking). Evolution in adulthood will depend on angulation at bone maturity:

- less than 50°, change of 0.8° per year,
- over 50°, change of 1.4° per year,
- Tetraplegic and spastic patients with a thoraco-lumbar or lumbar curve present the most progressive curvatures.

## SPINO-CEREBELLAR DEGENERATION

**Friedreich's disease**
Bilateral sunken feet, abolition of osteotendinous reflexes and cerebellar signs with balance and coordination disorders should suggest Friedreich's disease.
All patients had scoliosis of more than 10°, and 66% had Hyperkyphosis. Both sexes are equally affected. The distribution of curves shows little thoracic scoliosis but does show the following:
- double-major 60%,
- thoraco-lumbar 20%,
- lumbar 20%.

The early onset of the disease determines the severity of scoliosis, but there is no significant correlation with muscle weakness and gait quality. Cerebellar ataxia plays the greatest role in the onset of vertebral deviation. This type of scoliosis is more like an idiopathic scoliosis than neuromuscular scoliosis. The usual orthopedic treatment is the Lyon Method with adjustable ARTbrace, as for idiopathic scoliosis.

**Charcot-Marie-Tooth disease**
Bilateral hollow foot and thenar eminence atrophy suggest Charcot-Marie-Tooth disease. Scoliosis is found in 90% of cases, with a kyphotic component. Conservative orthopedic treatment is possible in almost half of cases. Caution should be exercised in cases of early onset and double curvature in boys.

**Syringomyelia**
4% of idiopathic scoliosis over 20° are thought to have syringomyelia. Scoliosis is the only symptom in 3/4 of cases. During clinical examination, we insisted on looking for an abdominal cutaneous whenever there was a slightly unusual curve with a large radius, sometimes in the left thorax, or in a boy, with a large imbalance during anterior flexion of the trunk. The association of scoliosis is not systematic, and cerebrospinal fluid diversion can cure scoliosis in a 5-year-old child. Nuclear magnetic resonance is used to make the diagnosis. Other clinical signs include nuchalgia and thermo-algesic dissociation.

## LOWER MOTOR NEURON DAMAGE

**Poliomyelitis**
The most common cause of paralytic scoliosis is poliomyelitis. The earlier the trunk muscles were affected, the more severe the scoliosis.

Two factors are essential to generate scoliosis;
1. Growth; in fact, there is no scoliosis when paralysis occurs in adulthood;
2. Muscle damage, which combines muscle weakness with veritable vertebral compression.

These muscular imbalances, due to asymmetric damage and muscular retractions at the level of paralyzed muscles, can sometimes oppose postural collapse. Respiratory damage can lead to general hypertrophy.

We have seen the pathophysiological factors involved in the genesis of deviations, which no doubt explain the clinical polymorphism complicated by pelvis deviations and severe thoracic involvement. The evolution of these scoliosis is similar to that of essential scoliosis.

However, certain characteristics separate them from idiopathic scoliosis, such as:
- early onset, on average within 2 years of disease onset;
- equal distribution for boys and girls
- the curves often have a large radius, characteristic of neurological scoliosis;
- Lateral imbalance is significant due to muscle weakness at the compensatory curve level; and
- extreme cervico-thoracic and oblique pelvis locations are much more frequent than in idiopathic scoliosis.





Therapeutic indications take these particularities into account. In young people, the worsening of these curves can make sitting impossible, necessitating treatment so as not to leave bedridden subjects who had been able to regain a degree of independence.

**Physiotherapy**
Paralytic scoliosis, in particular poliomyelitis, has benefited from treatment in the supine position in the initial phase. Precise movements are performed in a corrected attitude, with constant care taken not to aggravate functional imbalances. At the stage of definitive sequelae, especially in children and adolescents, strict and regular monitoring of spinal condition is essential. As soon as the spine worsens, orthoses (Milwaukee brace or Lyon corset) or surgery may be required, depending on the extent of the curve and the patient's age.
When angulation exceeds 50°, straightening and arthrodesis are the usual indications. If the thoracic and abdominal muscles are significantly affected, respiratory assistance is often required.

In the case of an oblique pelvis, unilateral femoral traction, sometimes combined with sectioning of the iliac crest muscles on the side of retraction, facilitates preoperative reduction. Surgical maintenance of the reduction is much more difficult.

Osteosynthesis is performed with fixation to the iliac crest or fin using a plate or staple. Segmental fixation osteosynthesis usually transforms the postoperative course, as there is no restraint, which is very poorly tolerated in these children.

**INFANTILE SPINAL MUSCULAR ATROPHY**
A distinction is made between the early form, or WERNIG-HOFFMANN disease, and the late form, KUGELBERG-WELANDER, which is discovered in late childhood or adolescence. Involvement of the anterior part of the spinal cord results in pure, diffuse motor paralysis, with no sensory impairment, predominating at the trunk level, respiratory muscles and limb roots. The clinical pattern is similar to that of poliomyelitic tetraplegia.

Almost all patients will develop scoliosis. Scoliosis is detected around the age of 4. A distinction must be made between scoliosis in walking children, which is amenable to orthopedic treatment, and scoliosis in wheelchair-bound children, which requires surgical intervention. In all cases, constant respiratory impairment dominates the picture.

**MYELOMENINGOCELE (spina bifida)**
70% of myelomeningocele cases will present with scoliosis. The curve will exceed 30° in 40% of cases, with an average progression of 5° per year. Deviation is generally observed at the age of 6 and progresses until the age of 15. The frequency increases with the degree of neurological damage and the existence of hip dislocation, but there is no correlation between the side of scoliosis and the side of dislocation (Fig 8.2).


Fig 8.2 Spina bifida

# Muscular scoliosis

## ARTHROGRYPOSIS

It combines stiffness and joint deformity. (Fig 8.3).

person can be noted;
- abolition of abdominal cutaneous reflexes points to syringomyelia;
- an unusually large C curve looks like a pathological curve.
- hollow feet and atrophy of the thenar eminences should lead us to look for Charcot Marie disease;
- Cerebellar disorders, hollow feet, areflexia, etc., point to Friedreich's disease.

### POSTURAL SCOLIOSIS?

- Around the age of 7, postural disorders are probably the determining factor. It is around this age that the child becomes lateralized.
- A habitual poor sitting position, but above all clumsiness when playing sport, can point us in the right direction and prompt us to seek out specific tests.
- The postural system matures definitively around the age of 13 in both sexes, which explains the greater frequency of scoliosis in girls (NOTOM).

### MUSCULAR SCOLIOSIS?

Thirty years ago, some authors considered that most scoliosis was due to a minor form of poliomyelitis. Poliomyelitis was often accompanied by scoliosis. However, this disease combines paralysis and muscular retractions. The side of the scoliosis does not correspond to the side of the paralysis, so it's the retractions that determine the scoliosis. It should be remembered that it was on poliomyelitic scoliosis that Duval-Beaupère defined her laws of scoliosis evolution during the growth period, which later proved partially applicable to idiopathic scoliosis. Unusual limb retractions in girls and a high, short thoracic curve may point to viral neuropathy.

### BONE SCOLIOSIS?

Collapse of the posterior vertebral wall is characteristic of scoliosis due to Recklinghausen's neurofibromatosis, which reproduces all the severe forms of idiopathic scoliosis up to and including rotatory dislocation. Some authors note osteoporosis associated with idiopathic scoliosis. A small, bluish sclera and dental problems should point to a minor form of Lobstein's disease.

### HYPERLAX SCOLIOSIS?

Excessive flexibility may suggest a benign joint hypermobility syndrome, which is accompanied by scoliosis in 20% of cases.
Five clinical signs have been described:
1. Passive hyperextension of the index finger beyond 100°,
2. Thumb-radius contact during forced wrist flexion,
3. Elbow hyperextension greater than 10°,
4. Knee recurvatum greater than 10°,
5. Hands flat on the floor, knees stiff.
Each limb is scored out of 10. Hyperlaxity is perceptible above 5.
In this syndrome, physiotherapy will avoid stretching and will seek to strengthen the musculature, the true active ligament of the joint.

### PARADYSPLASTIC SCOLIOSIS?

These are long-limbed, hypotrophic children, often presenting with a dolichostenomelia appearance without large stature or ocular anomalies. There is often a decrease in the anteroposterior diameter of the thorax. The hump is angular and larger than the angulation would suggest. Scoliosis in this context is often formidable, as the brace is poorly supported on the rib cage.

***CONCLUSION***

*The symptom of scoliosis associated with other diseases gives us a better understanding of the pathogenesis of so-called idiopathic scoliosis. These diseases affect the vertebrae in congenital scoliosis and spina bifida, the muscles in poliomyelitis and myopathy, the balance system in Friedreich's disease, connective tissue in Marfan's disease and Ehlers-Danlos syndrome, ectodermal nervous tissue and bone in Recklinghausen's disease. We have seen that many intermediate forms exist between these pathologies and idiopathic scoliosis. While some colleagues believe that there is no such thing as idiopathic scoliosis, we would like to draw attention to the risk of unnecessarily adding a diagnosis to that of scoliosis, which is already difficult for the child and his or her family to accept. We must be vigilant, but wary of labels.*





*Chapter 9*

# 9. From attitude to structurality

**"Beauty is generated by minimal transitions through many numbers."**

**Polyclitus' Cannon**

Polyclitus, a Greek sculptor, sought to represent in his statues the beauty of the man recognized and venerated on the stadia, and the scrupulously measured Doryphorus may have served as a reference for Renaissance scholars in fixing the ideal canon. It presents a typical scoliotic posture, like the anatomical diagrams of Vesalius. Life is movement, and the spine is constantly oscillating from one scoliotic attitude to another. Occasionally, this harmonious mechanism is disrupted, resulting in a scoliotic attitude.

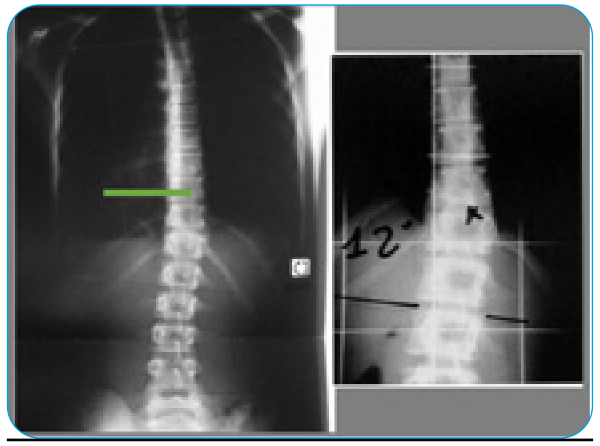


Fig 9.1 Paradoxical scoliosis

## Paradoxical scoliosis

The posterior arch of a structural scoliosis usually rotates towards the concavity, in the direction of Ian Stokes' vicious circle. In some cases, rotation is in the opposite direction, towards convexity, as if rotation were compensating for lateral inflection. This is one of the rare cases where the prognosis is favorable (Fig 9.1)
.

## Scoliotic attitude

Irreducible structural scoliosis is usually contrasted with clinically and radiologically reducible scoliotic attitudes. The clinical examination must be carried out with the same rigor as for structural scoliosis. The "end-of-table" position we have described can be used to rule out a length discrepancy of the lower limbs.
There are 3 categories of scoliotic attitudes:
1. consequence of a known pathology,
2. consequence of a postural defect,
3. consequence of a psychiatric disorder.

### SCOLIOTIC ATTITUDES AS A CONSEQUENCE OF KNOWN PATHOLOGY OR COMPENSATORY SCOLIOSIS

### PATHOLOGY OF INFERIOR CAUSE

The most frequent cause is unequal length of the lower limbs. An inequality of 5 to 10 mm is very common, as the growth of the lower limb occurs sometimes on the right, sometimes on the left. Clinically, the examination is initially performed without compensation. The shorter side is noted, and the measurement should be consistent both posteriorly at the level of the iliac crests and anteriorly at the level of the anterior-superior iliac spines. When there is a discrepancy, with a higher right iliac crest and a lower right anterior superior iliac spine, we speak of pelvic rotation. The location of the lumbar hump is noted when the child leans forward. The false hump is located on the side opposite the shorter side. When the second examination is performed after compensating for the imbalance, the deformity disappears (Fig 9.2-3).

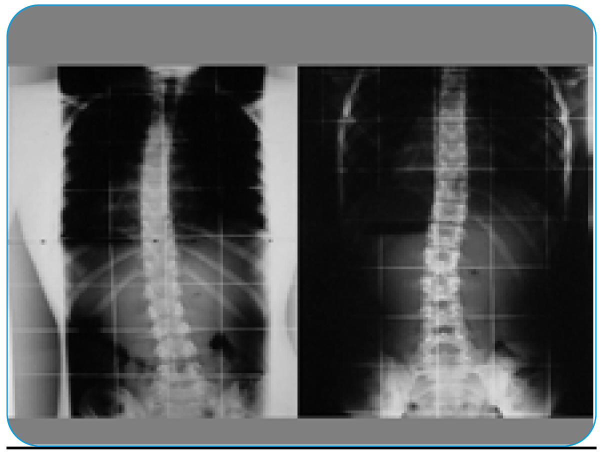


Fig 9.2 Scoliosis due to unequal length of lower limbs

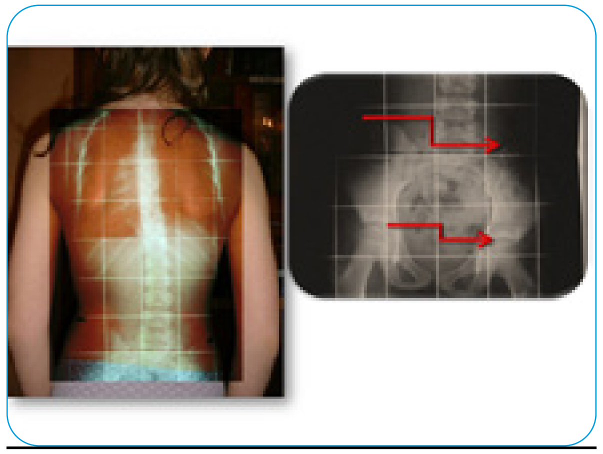


Fig 9.3 Improving hump by compensation

In this case, the imbalance must be compensated by fitting a board of appropriate thickness under the shorter lower limb. A compensation of 2/3 is generally chosen, so as not to inhibit spontaneous correction during growth. In some cases, the patient retains a poor scoliotic attitude, which can be corrected by physiotherapy.

At the end of growth, it's important to compensate for this inequality, as American insurance statistics show that beyond 2cm of inequality in the length of the lower limbs, the risk of low back pain is twice as frequent in adulthood.
Hip stiffness and ankylosis in a vicious attitude will also cause the pelvis to become unbalanced.

It is important to differentiate this scoliotic attitude of inferior cause from structural scoliosis with length inequality of the lower limbs. In this case, the hump is on the shorter side. When the second examination is carried out after compensation with a board under the shorter lower limb, the hump is generally seen to worsen. This is compensation for scoliosis of the lower limbs, and when this inequality is slight, it should not be compensated for by a heel-piece. In this situation, knee pain is frequently noted, which may reflect a global counter-rotation of the whole lower limb, a consequence of the scoliosis.

## MEDIUM-CAUSE PATHOLOGY

All early vertebral disorders can cause contractures, often asymmetrically. This should always be borne in mind in the presence of a large-radius curve, painful scoliosis or stiff curvature. This is the usual attitude in infantile hemiplegia.
Asymmetrical paravertebral retractions or contractures can lead to scoliosis, for example in the after-effects of poliomyelitis. In children, this attitude almost always becomes structural in the years following spinal cord injury. Symptomatic scoliosis is common. Here again, the curve is often structured.





## PATHOLOGY OF SUPERIOR CAUSE

The mechanism is identical to middle cause attitudes. Torticollis retractions affect the sternocleidomastoid. Paralysis affects the scapular girdle.
All painful conditions of the neck, scapular girdle and upper limbs can lead to antalgic attitudes with a scoliotic curve.

## SCOLIOTIC ATTITUDE DUE TO POSTURAL DEFECT OR POSTURAL SCOLIOSIS

It's a misunderstanding of the symmetrical standing or sitting position. Habitual poor posture has probably given the child an erroneous awareness of spinal balance. Clinically, the curve is of large radius, with a difference in shoulder level. Standing up straight" can make the curve disappear. Tonic regulation is involved in this balance, and parents often speak of a hypotonic attitude. Unlike the progressive development of muscle strength, muscle tone varies. Hypotonia is physiological up to the age of two, and occurs in the prepubertal period.

A distinction is made between unstable forms, with full correction in front of the doctor, and permanent forms. Later on, the patient may no longer realize that he or she is holding himself or herself awkwardly, at which point physiotherapy, sometimes quite lengthy, may be required. This attitude is very common in asymmetrical sports such as fencing, as we'll see in Chapter 15. We also observe it in visually impaired children and violin players.

Radiologically, there may be a reverse rotation of the inflection, as if the rotation compensated for the lateral inflection, with the spinous process rotating on the convex side.

## PITHIATIC SCOLIOTIC ATTITUDES

This is a conspicuous scoliosis that disappears during natural or anesthetic sleep. Appropriate psychotherapy can make this symptom disappear without the appearance of other localization disorders. Be careful not to confuse symptomatic scoliosis, spinal tumors and pithy scoliosis. Mistakes are made in both directions, with patients unnecessarily inventoried for neurosurgery and those whose tumors are allowed to develop under the pithy label (Fig. 9.4).

Fig 9.4 Dystonic scoliosis

## Scoliotic Attitudes Physiotherapy

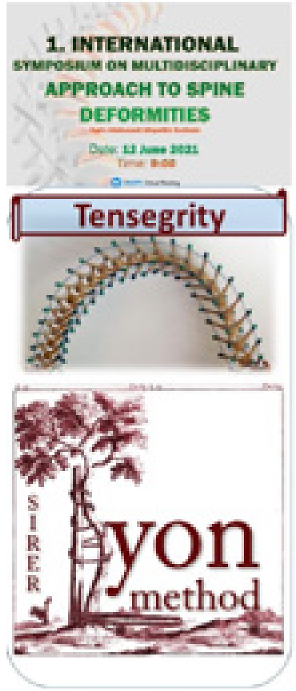
**GENERAL**

We need to distinguish between the paramorphism or simple bad posture of a normal child and the scoliotic posture of a child with obstetrical brachial plexus sequelae. Physiotherapy is obviously more appropriate for the latter, while adapted sports and a good workstation are generally sufficient for the former.

The child may present different types of patterns on examination including:
- an asthenic passive attitude with varying degrees of relaxation under the effect of gravity: "he's hanging on his ligaments and askew";
- an aspect of instability, of being restless, unable to remain still even for a short time;
- with an additional psychomotor handicap; dyslexia, dysgraphia, lateralization difficulties;
- more or less complex, unfulfilled behavior. The child feels bad about himself;
- a major motor or sensory handicap; blindness, neonatal hemiplegia, congenital amputation of an upper limb, etc.

The child comes into contact with himself, with the physiotherapist and with corrective on the lower jaw. The brace protects against all postural changes.

***In conclusion,***
*This presentation covers the new elements of the Back School for scoliosis and completes session 3.4 of the Certification with Sport, binder and sitting position. Ideally, you can add a page on your own website for your patients to consult.*









*Chapter 10*

# 10. From progression to chaos

> ***"For lack of a nail, we lost the iron;***
> ***for lack of a shoe, we lost the horse;***
> ***for want of a horse, we lost the rider;***
> ***for lack of a rider, we lost the battle;***
> ***Losing the battle, we've lost the kingdom!"***
>
> ***Folk rhyme***

Folklore illustrates that a succession of events can reach a critical point beyond which a small initial disturbance can assume gigantic proportions. Chaos means that such critical points exist everywhere, including in scoliosis. Over the past 20 years, mathematicians and physicists have attempted to explain nature's irregularity, discontinuity and disorder through chaos theory.

Edward Lorentz is a meteorologist. From his window at the Massachusetts Institute of Technology, he contemplates the clouds. On his computer, a "Royal Mac Bee" that takes up a large part of his office, he reconstructs the movement and speed of winds on an ideal globe, and every hour, digitized cyclones are displayed on listings. This machine, which would seem rudimentary today, impresses his colleagues. Using his computer, Lorentz reduced the atmosphere to a dozen or so equations, and little by little the system revealed its secrets. One winter day in 1961, Lorentz tried to increase the forecasting time. He took a shortcut: instead of starting at the beginning of his program's execution, he began halfway through, i.e. he manually introduced the initial conditions into the machine by typing in numbers taken from the last listing. This new execution should have exactly reproduced the old one over the period of time already explored; Lorentz himself had introduced the numbers into the computer and the program was identical. However, when he examines the new listing, he finds that the numerical weather forecasts are totally divergent to the point where there is no resemblance between them. Suddenly, he realized the truth: the computer was storing 6 digits after the decimal point, whereas this precision was only 3 digits for space reasons on the listing. The truncated digits have been introduced into the machine, and this small difference of 1 per thousand, quite negligible in view of the usual precision of data collection, will set off a storm in the computer. Lorentz has just formalized chaos theory.

But to return to our scoliosis, we have to acknowledge that, although we are relatively familiar with the laws of bone growth, nervous and muscular physiology, vertebral biomechanics, the experimental factors that reproduce scoliosis, and the pejorative clinical elements.... We are unable to predict the evolution of a scoliosis of less than 20°.

When, in 1989, Mrs. Duval-Beaupère looked for all the criteria that could be used to predict the progression of scoliosis during growth, she was only able to select one factor with a 95% confidence interval: scoliosis angulation greater than 35°, i.e. scoliosis in which the posterior wall of the apical vertebra had already collapsed. The earthquake had already passed.

In 1876, Maxwell wrote: "When the state of things is such that an infinitely small variation of the present state will modify the future state by only an infinitely small quantity, the state of the system at rest or in motion is said to be stable. But when an infinitesimally small variation in the present state can cause a finite difference in a finite time, the state of the system is said to be unstable. Clearly, the existence of unstable conditions makes it impossible to predict future events if our knowledge of the present state is only approximate, not exact."

According to Maxwell, the spine is an unstable system, like a pencil on its point. However, we know that the spine behaves more like an inverted pendulum, and is in fact a stable oscillating system. Traditional mechanics cannot therefore explain the development of scoliosis.

Unlike classical Euclidean geometry, the new geometry of chaos presents the universe as angular rather than rounded, rough rather than smooth. It's the geometry of the twisted, the dislocated, which applies perfectly to scoliosis. Nature is profoundly non-linear. A chaotic system is stable if its disordered character is generally maintained in the face of small disturbances, like the lead ball shaken to the bottom of the bowl. So a complex, stable system like the balance of the spine can generate turbulence; scoliosis. Reading Edward Lorentz's description of the "butterfly effect" or "Can the flapping of a butterfly's wing in Brazil determine a tornado in Texas", we can't help thinking that a small defect in the dental articulation, a bad attitude, an inequality in the length of the lower limbs... can trigger scoliosis, and only chaos theory provides a model for this.

If we accept this model, as with meteorology, we can distinguish between blue skies with no scoliosis, cloudy skies with scoliotic attitude or, on the contrary, stormy skies with progressive structural scoliosis. Sometimes it's a storm, with an annual progression of over 15°. It will be impossible to make long-term forecasts, and we'll have to be content with carefully monitoring scoliosis to protect the spine before the tornado strikes. Gathering as much clinical information as possible is essential if the weather report is to be satisfactory. But it will also be illusory to try to prevent the evolution of scoliosis with a pill or a miracle method of physiotherapy or braces, even if certain physiological bases are correct. Let's take a look at the warning signs of the storm.

## Progressive prognosis

**DEFINITION**

For this definition, 3 criteria were selected:

1 Any scoliosis whose angulation before bone maturity exceeds 30° warrants heavy orthopedic treatment or, according to Ponset"s work,will evolve into adulthood. Scoliosis can therefore be considered progressive. In 110 cases of minor idiopathic scoliosis (10° to 30°) consulted between 1950 and 1966, 35% were progressive. It should be noted, however, that given the consultation times of around 6 months, progressive scoliosis already exceeded 30° at the time of consultation.

2 Any scoliosis whose angulation evolves in the upright position beyond the radiological error limit of 5° can be considered progressive. For 70 patients with minor idiopathic scoliosis who consulted between 1960 and 1970, 56% were progressive according to this criterion.

3 Any scoliosis whose angulation worsens by more than 10° beyond 20° of angulation can be considered progressive, whatever its angulation. Under these conditions, Salanova considers that 62.4% of idiopathic scoliosis is progressive before bone maturity.

PROGNOSIS OF ESSENTIAL SCOLIOSIS AT FIRST EXAMINATION BEFORE BONE MATURITY





Three elements appear to be fundamental when looking at the research:

1. Gender: if we exclude infantile scoliosis, 80% of idiopathic scoliosis occurs in girls, but the progression of scoliosis is often more marked in boys.

2. Patient age: before puberty, between puberty and bone maturity, after bone maturity. Juvenile scoliosis is twice as progressive as adolescent scoliosis.

For Bunnel (1993), before the age of 10:

- 88% of scoliosis will worsen by more than 5°;
- 68% of scoliosis seen before menarche will progress by more than 10°;
- according to the Risser test, the risk can be represented as follows (Table 10.1).

| Risser | Risk of aggravation |
|---|---|
| 0 | 68% |
| 1 and 2 | 52% |
| 3 and 4 | 18% |

Table 10.1 Aggravation risk according to Bunnel

3. The degree of angulation: less than 30°, from 30° to 50° and more.

At present, the French social security system sets the threshold for full coverage of treatment at 30°.

Bunnel specifies rates of change of more than 5 or 10° Cobb angulation (table 10.2).

| Standing | Progression > 5° | Progression > 10° |
|---|---|---|
| < 20° | 70% | 44% |
| 20° - 29° | 52% | 30% |
| 30° - 39° | 67% | 48% |
| 40° - 49° | 78% | 62% |

Table 10.2 Risk of progression as a function of angle (Bunnel)

Lonstein (1984) used the Risser test. He studied 727 cases of idiopathic scoliosis with an angulation of less than 30° and followed them through to bone maturity. The lower limit was 5°. Under these conditions, 23% of scoliosis is progressive (1).

A nomogram shows the progression rate as a function of the progression factor.

Vidal and Perdriolle (1993), for juvenile thoracic and thoraco-lumbar curves, calculate the specific rotation angle represented by the sum of the rotations of the vertebrae above and below the upper limiting vertebra (table 10.3).

| Specific angle of rotation 6 years to Risser 1 | Final Cobb at Risser 5 |
|---|---|
| RS <8° | < 35° |
| 8°< RS < 12° | 35° -.50° |
| 12° < RS < 30° | 50° - 110° |
| RS > 30° | > 110° |

Table 10.3 Progressive risk as a function of rotation (Perdriolle)

When scoliosis exceeds 35°, it can be interesting to predict the extent to which this curve will evolve. Yamauchi (1988) proposes five radiological factors;

- Xl= Cobb angulation in standing position,
- X2 = Angle of rotation of the apical vertebra,
- X3 = Deviation in mm of the center of the apical vertebra from a vertical lowered from the center of Tl,
- X4 = Risser coefficient (Cobb standing-Cobb lying) x 3,
- X5 = Bone maturity coefficient = Risser test +1.

Since Y is the expected angular progression, we can use the following equation;

Y= 7.7 + 0.132 Xl + 0.286 X2 + 0.258 X3 + 0.295 X4 + 1.620 X5.

### PROGNOSIS ACCORDING TO ANATOMO-RADIOLOGICAL TYPE AFTER BONE MATURITY

A scoliosis of more than 50° in adulthood will evolve on average as follows:

(1) We use the lower limit of 10° to refer to scoliosis, so our overall rate of progressive scoliosis is higher. This remark does not change the test.
Only the Risser test is significant for the factors studied. A progression factor is calculated according to the following formula; progression factor= [angulation- (3xRisser)] / chronological age.

have shown that orthopedic treatment stabilizes the evolution in over 80% of cases.

In all cases, the child must be advised, taking into account his or her sporting activity and school environment.

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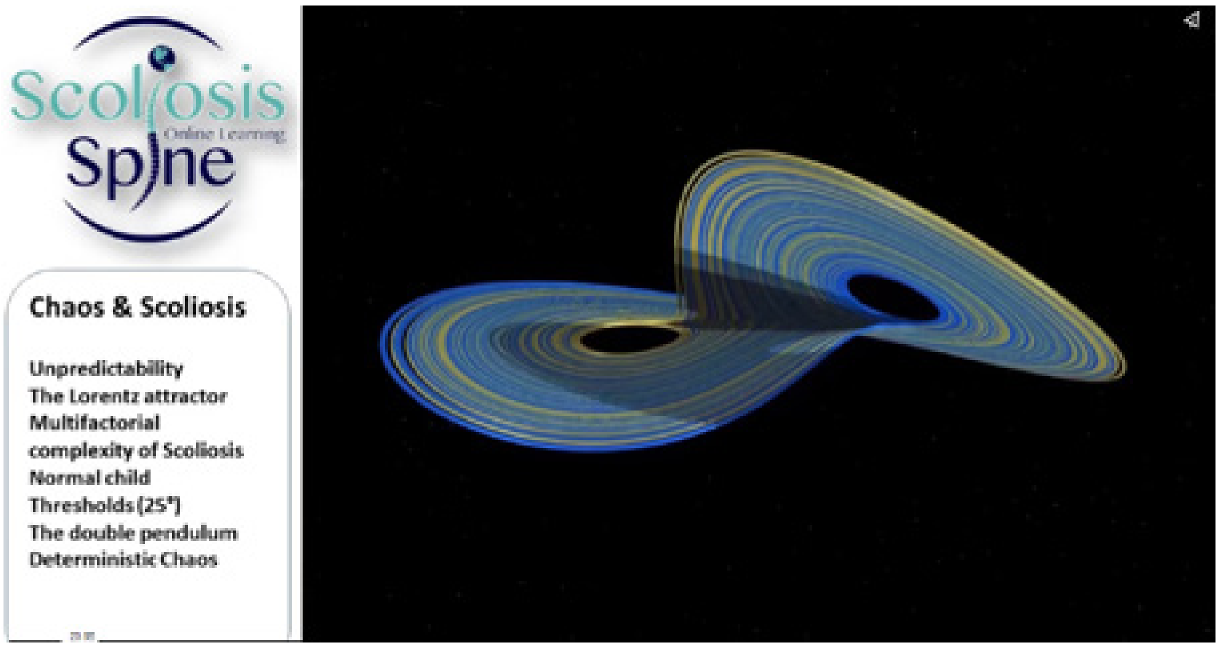







*Chapter 11*

# 11. From gymnastics to physiotherapy

> **«In forty years of practice, I have witnessed the birth and prodigious development of physiotherapy. You owe it to the rigor you increasingly bring to the definition of your therapeutic acts and to the critical evaluation of long-term controlled results.»**
>
> **Pierre STAGNARA**

## History of Physiotherapy

- 3000 years before JC in India, yoga includes a system of respiratory gymnastics "*the pranayamas*".
- In 2698 BC in China, the emperor Hoang-Ti developed a therapeutic gymnastics and published a book entitled "*Gymnastics and Physical Education*".
- In 1000 BC, the Chinese priests practicing the Tao use therapeutic postural and respiratory exercises called "Cong Fu".
- In 500 BC, the Greek temples of Asclepios in Cos and Epidaurus were places of systematic helio and hydrotherapy. The general term for exercise is "asceci": an ascetic exercises his mind and body. Athletes are those who exercise only to obtain a prize "athlon".gymnastic exercises are then practiced naked "gymnos".
- In 90 AC, Asclepiades introduces in Rome the exercises of musculation against resistance that he learnt in Greece.
- In 160 AC. Galen straightened a deformed thorax by strengthening the oblique muscles of the trunk and breathing exercises. He creates the term scoliosis.
- In 1650, Glisson publishes the first results obtained in the deformations of the spine.
- In 1741, Nicolas Andry creates the term "Orthopedics" and describes vertebral gymnastic exercises.
- In 1779, Jesuit Father Jean Jacques Amiot brings from China the "Cong Fu" method of postural and respiratory exercises 'Fig. 11.1).

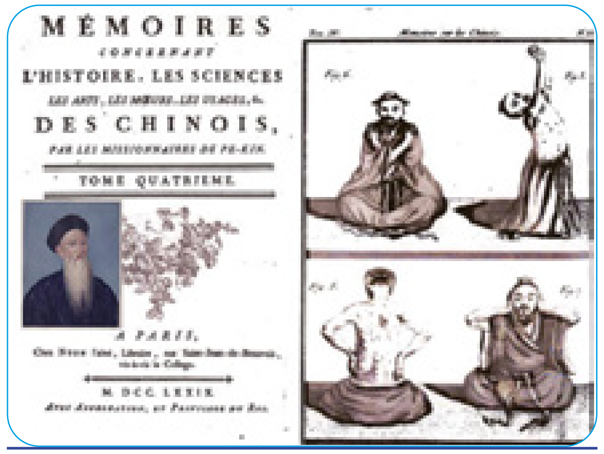



Fig. 11.1 Chinese Cong Fu

- In 1800, Ling described in Sweden specific postural correction movements, both static and against resistance adapted from "Cong Fu" (Fig. 11.2).

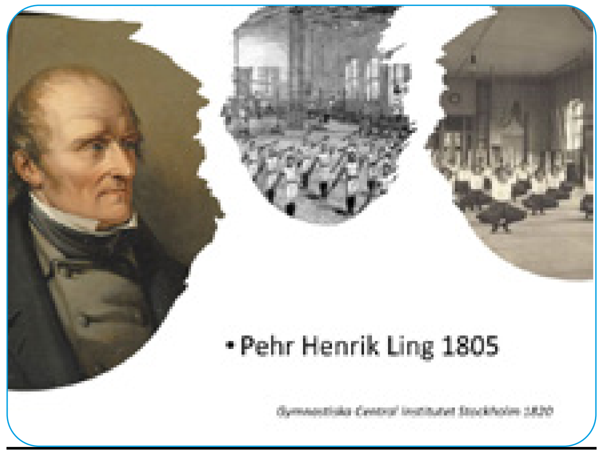



Fig. 11.2 Ling adapts Cong Fu in Sweden

- In 1824, a French physiologist, Jean Pierre Flourens, published his first work on pigeon scoliosis after destruction of the labyrinth, although he had expected simple deafness. This was the first experiment on the vestibular postural system (Fig. 11.3).

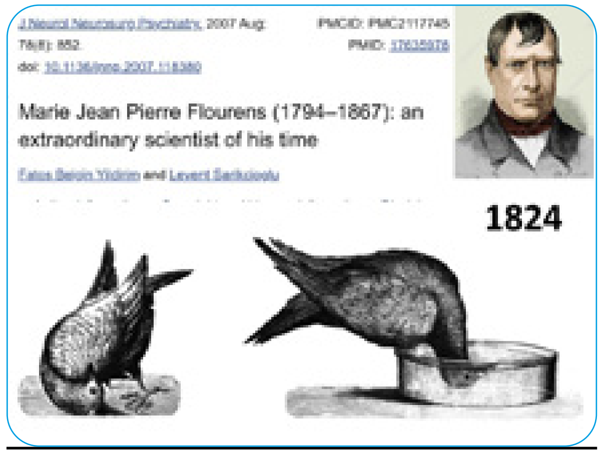



Fig. 11.3 Pigeon scoliosis due to destruction of the labyrinth

- In 1827 Pravaz, the inventor of the syringe and a former student of the Ecole Polytechnique, introduces the cosine in the analysis of the forces that can correct the curvature in his work *"New method for the treatment of the deviations of the spine"*. He opens an *"Orthopedic and Pneumatic Institute"* in Lyon. Pneumatic, because he used compressed air to correct thoracic deformities from the "inside" (1) (Fig. 11.4).

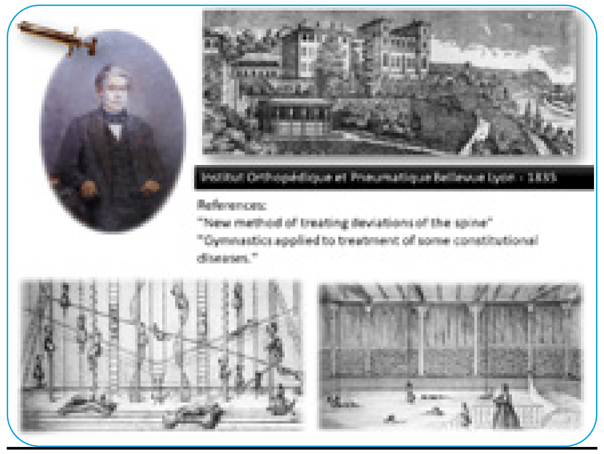



Fig. 11.4 Pravaz creates the Lyon Method (First in Europe)

Passive correction procedures by mechanical means are combined with active exercises. The orthopedic swing is an excellent device for proprioceptive physiotherapy of the spine stimulating the extrapyramidal system.

- In 1828, Delpech created a school near Montpellier for young girls suffering from scoliosis. He points out that *"gymnastics is so appreciated there, that it has been sown under the steps of the patients, that it is reproduced there in always new forms and suitable to pique curiosity and to revive emulation and prevent lassitude"*.
- In 1857, Dally coined the term "kinesiology", meaning the use of body segment or whole-body movement.
- Lorentz (1886) and Hoffa (1905) developed a treatment based on passive spinal flexion corrections, similar to Pravaz.
- In 1900, Zander in Sweden introduced mechanotherapy with pulleys, levers and weights. A French center in Aix-les-Bains is still in operation today.

From 1900 onwards, "methods" developed in Germany; Klapp introduced quadrupedia therapy to the treatment of scoliosis (1905). He actively mobilizes the spine by strengthening the back muscles, and points out that at least 2 hours of exercise a day are needed to achieve results. Some critics point to the possibility of aggravating counter-curves.

Schrott first taught gymnastic exercises (1910) and founded her institute in Meissen in 1921 to treat scoliosis. Based on the reactions of her own scoliotic body, she developed specific corrective mechanisms and emphasized "concavity-oriented breathing". Von Niederhoffer works the transverse muscles isometrically against resistance (1929). Kohlrausch and Teirich-Leube created the reflex massage. Schultz emphasizes the active regulation of muscle tone in his autogenic training.





# Physiological basis

## 1. Mechanics

Scoliosis is a multifactorial condition that develops discontinuously. Collapse of the concave posterior wall produces mechanical slippage often seen in conjunction with:
- shearing caused by the collapse of one of the tripod legs.
- torsion, which is initially slowed down by the musculature and which, beyond a threshold of around 30°, is accentuated by all the mechanical elements we are about to consider;
- rotational translation when the vertebra is at the thoracolumbar hinge, for example.

According to the chaos theory considered in Chapter 10, multiple factors that we are becoming increasingly familiar with can cause slippage. As with earthquakes, there are areas at risk, but it is impossible to predict the earthquake that will shake the concave posterior wall. In the first instance, the physiotherapist's role is to reinforce the spinal construction according to a number of anti-seismic standards.

## 2. Postural neurology

Following Flourens' description of pigeon scoliosis obtained after destruction of the vestibular labyrinth, one of the pillars of the Lyon Method is stimulation of the extrapyramidal system and its 4 pathways: reticulospinal, vestibulospinal, rubrospinal and tectospinal. It was only at the end of the 20th century that the role of delayed maturation of the extrapyramidal system in idiopathic scoliosis (NOTOM) was demonstrated.

# Anatomical base

### THE MUSCLE

It includes 2 systems:
- the short, deep, static muscles of the gutters, responsible for erection and spinal stability (type I aerobic extrapyramidal fibers).
- long, dynamic, superficial muscles with a kinetic role (type II anaerobic pyramidal fibers) (Fig 11.5).

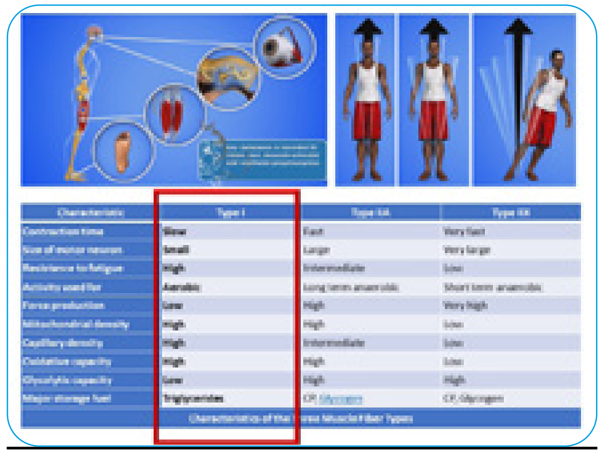


Fig. 11.5 The extrapyramidal postural system is the basis of the Lyon Method

Shortening of the concavity muscles leads to weakening. Energy production in anaerobic metabolism is ensured by liver enzymes under the influence of sex hormones. Maximum efficiency is achieved at the end of puberty.

Consequences:
Strengthening of static muscles through aerobic metabolism, i.e. careful control of breathing without forcing, through endurance.

### GROWTH PLATE

It is subjected to asymmetrical pressures that cause a structural change in the apical vertebral body from rectangular to trapezoid, ac-





*Chapter 12*

# 12. From the Stagnara brace to the ARTbrace

**The treatment of scoliosis, the opprobrium of orthopaedic surgery, has entered a new era of unlimited progress. It is now truly within our power to cure scoliosis.»**

**F. CALOT**

## Specific terminology

The brace is the medical device for deformity, functional complement, prevention, correction and support.
For the spine, the following terminology is used;

### *SUPPORT*

Contact zone between the body and the brace. Support can be variable, permanent or intermittent.

### *ARTbrace*

Stands for Asymmetry, Resistance, Torsion brace.

### *BASE*

Part of the brace designed to secure the brace to and against the trunk (pelvic or scapulothoracic base).

### *STOP*

Part of the brace that limits movement, most often used to limit expansion in the concavity.

### *CAD/CAM*

Acronym for "computer-assisted design and manufacture", which refers to computer-assisted moulding and production of the positive. This system replaces the old moulding and plaster positive.

### *COUNTER-SURFACE*

Area of contact that opposes support.

### *VALVE*

Hinged or movable hull segment.
Rigid part of a brace that covers the entire body segment.

### *CREMAILLERE FASTENER*

Specific, very precise fastening, also used for sports shoes.

### *MAST*

Vertical beam attached to the seat, including the attachment of supports, stops or rappels. The mast can be straight, curved, of variable height and adjustable.

## SHIFT

The Lyon shift is a scoliosis correction movement combining translation and axial traction. In the case of the ARTbrace, elongation is limited by the priority sagittal plane.

## MATERIALS

For temporary reduction braces, **fast-drying plaster** provides the best modeling, and retains excellent skin tolerance, particularly with regard to perspiration. The disadvantage is the 10-minute setting time, which makes moulding in the corrected position difficult.

For permanent braces, we will list the materials in order of strength:

Plastic fabric with a resistance of over 350 centiNewtons per centimeter at 30% elongation, or resistant 4-thread checkerboard ticking, generally reinforced with whalebones.
Leather used for straps, SPITZY collars. It can also be used in the general construction of braces for neurological patients. Skin tolerance is excellent, but urinary incontinence may limit its use.
**Plastazote** or other foams heat-bonded to the base material to distribute pressure more evenly.
**Polyisoprene** can be processed at 50° and molded directly onto the patient, whose skin is protected by a jersey. The disadvantage of this material is that it deforms at room temperature.
**Polyethylene**, obtained from the polymerization of ethylene monomer, is 3 to 5 mm thick and can be processed at 100° and above. It is generally reinforced with steel. This is the most widely used material, but its strength is low (25 Newtons/mm2).

The **polypropylene** obtained by polymerizing propylene monomer is processed at over 200°. It is vacuum thermoformed. The ribs increase rigidity and eliminate the need for metal reinforcements. It can be welded, is unbreakable below the elastic limit and can be used for hinges.

Cylindrical polyurethane used for positive milling.
**Plexidur or acrilonitrile-methyl-metacrylate** copolymer, thickness 4 to 5 mm, can be worked between 140° and 170° and its strength allows direct tapping.
**EUROPLEX "O" OR POLYAMIDE 6** is the strongest (170 Newtons / mm2) (Fig 12.1).


Fig 12.1 Polyamide 5 times stronger than polyethylene

Skin tolerance is excellent, as silk is a natural polyamide (Fig 12.2) and is a shock absorber (Fig 12.3)

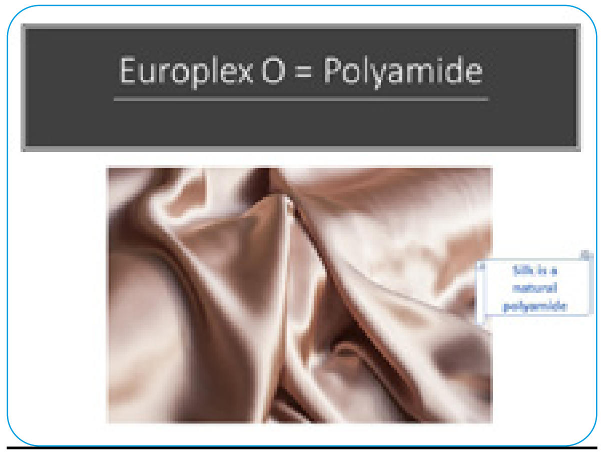



Fig 12.2 Silk is nature's polyamide





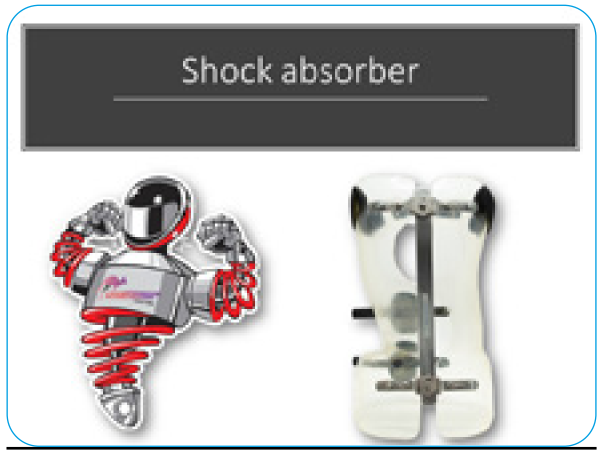



Fig 12.3 Polyamide is a shock absorber

- Duralumin for masts.
- Carbon fiber

# Biomechanical principles

## IN CHILDREN;

- All braces guide growth during the night.
- Unloading of the vertebral body, and in particular the posterior wall, is achieved by extension between the pelvic girdle and the scapular girdle, and by the composite beam effect at trunk level, especially in symmetrical braces (Fig 12.4).

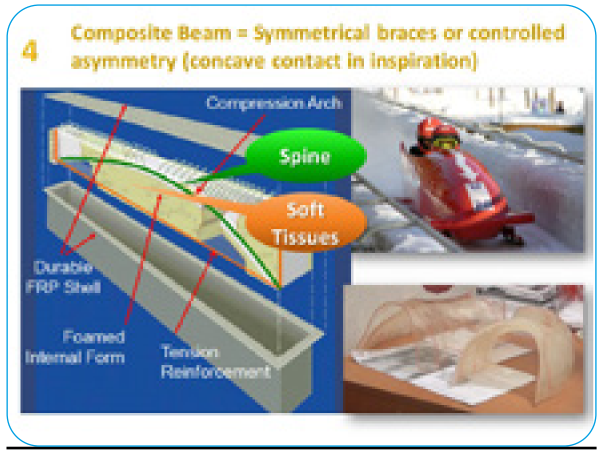



Fig 12.4 The ARTbrace is a composite beam that reduces pressure on the vertebral axis.

- Shaping thoracic prominence is thanks to the frontal and sagittal action of the brace at the ribcage level. In the frontal plane, contact is accentuated at the anterior concave chondro-costal level, with posterior concave expansion. In the sagittal plane, the two lateral hemi-valves remodel the thoracic cylinder (Fig 12.5).

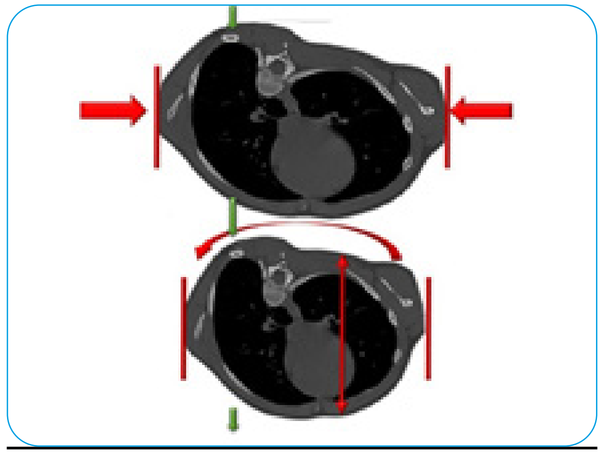


Fig 12.5 Reharmonization of thoracic volume

- Paravertebral creep is ensured by full-time (24/24) wear of a brace reducing the curve by more than 48% on average. Full-time wear varies from 1 to 4 months, depending on the initial angulation of the curve. Today, ARTbrace replaces the old plaster cast. An asymmetry that maintains maximum contact surface increases the possibility of correcting the curve (12.6).

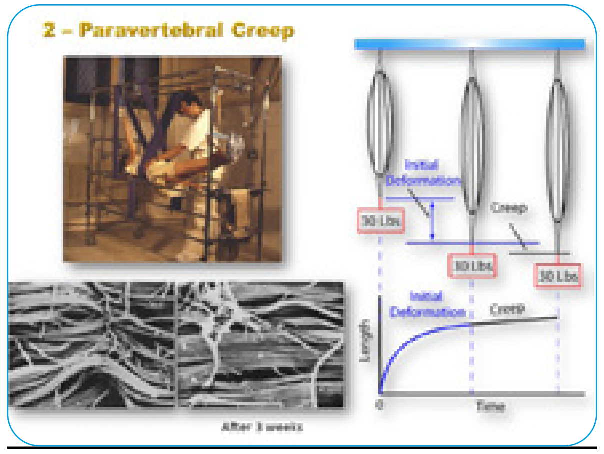
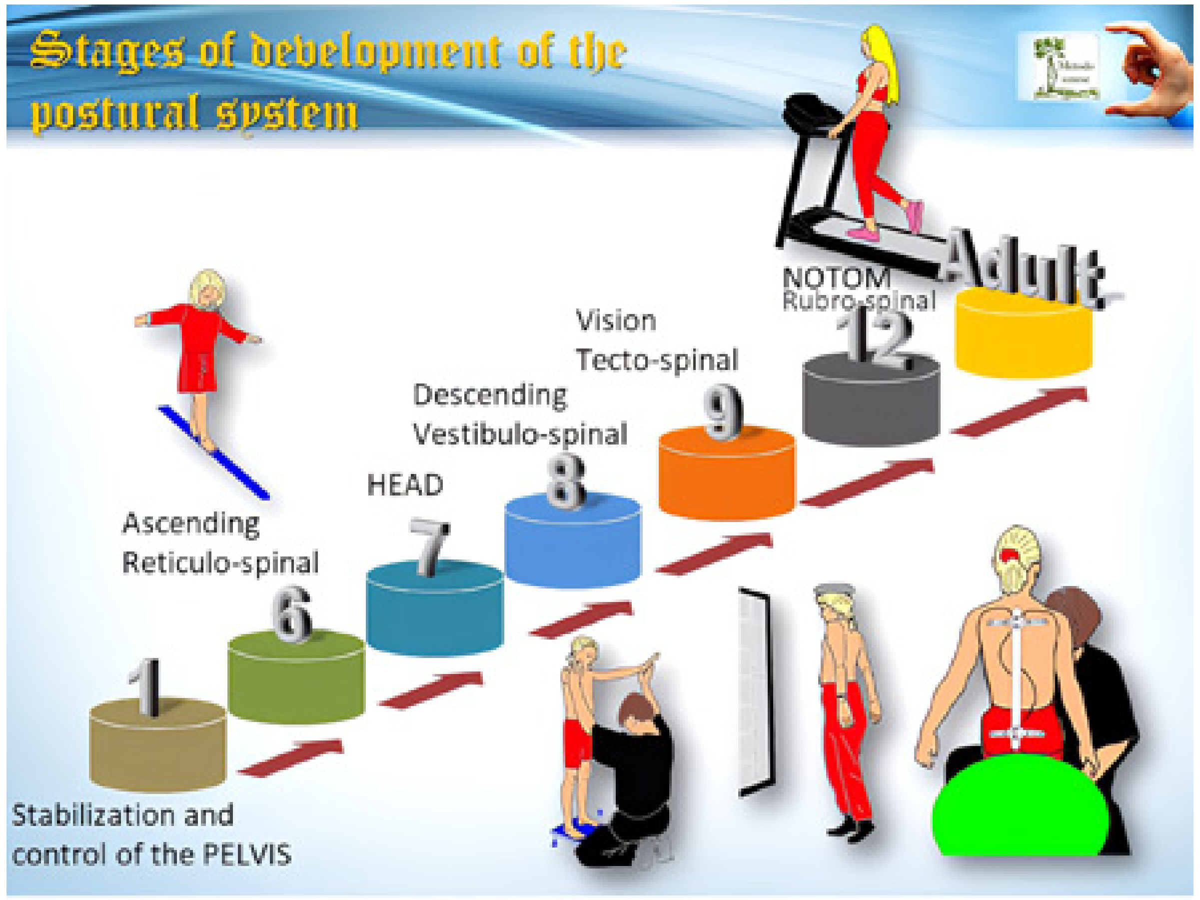
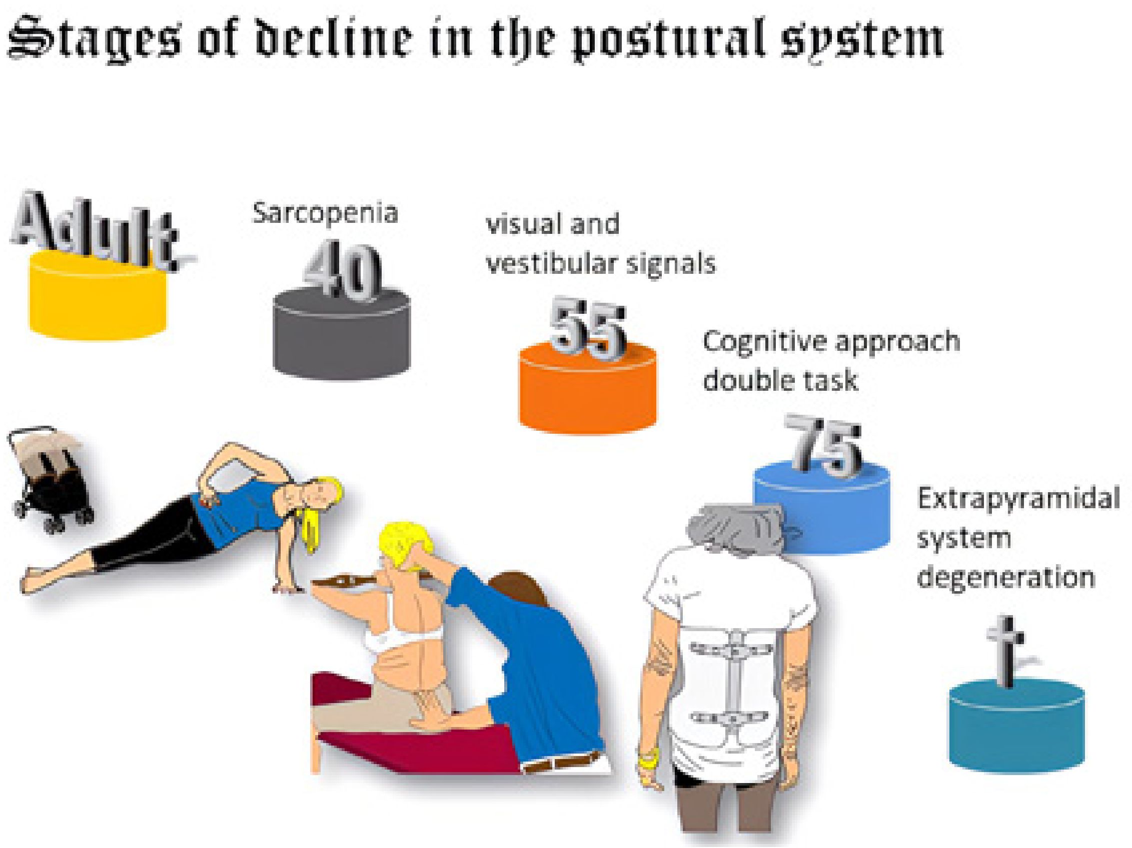



Fig 12.6 Creep with plastic deformation

The brace's soft-tissue action means that non-surgical treatments can be considered after Risser 2, and corrective braces in adulthood.




*Off-text illustration: The postural system evolves throughout life. While the principle of stimulating the postural system remains the same, it needs to be adapted to each age group according to its capabilities.*





*Chapter 13*

# 13. From infantile to adult scoliosis

**"But much more characteristic are the hypotrophies that accompany certain infantile scoliosis. This particular form; early hypotrophic scoliosis, poses difficult problems because the scoliosis seems to aggravate the hypotrophy and vice versa..."**

**Pierre STAGNARA**

## Newborn scoliosis

Classically, this is an idiopathic scoliosis discovered before the age of one. The most common case is a boy with a large-radius left thoracic curve, with moderate rotation that is nonetheless structural because it cannot be reduced. As these children are undressed every day by their mothers, it is rare for a hump to go unnoticed.

Clinically, plagiocephaly is the most common feature, with the head deformed into a torticollis shape without retraction of the sternocleidomastoid. This appearance is relatively common, even in non-scholiotic newborns.

The evolution of scoliosis in newborns is generally favorable, with 80% of cases resolving before the age of 6. It appears that American newborns who sleep on their stomachs do not have this deformity.

Mehta's work (1972) quantified vertebral rotation and prognosticated its evolution. His study involved 138 children whose scoliosis began before the age of 2, followed radiologically and clinically.

The degree of costovertebral angle (RVAD) was measured on a frontal X-ray at the vertebral apex level. A perpendicular is drawn at the level of the lower edge of the vertebra. Two straight lines running from the neck of the concave and convex ribs intersect this perpendicular. The intersection with the perpendicular forms a smaller angle on the convex side. The difference between these two angles is the Mehta index. Phase, the projection of the neck of the convex vertebra onto the edge of the vertebral body, can also be measured (Fig 13.1).

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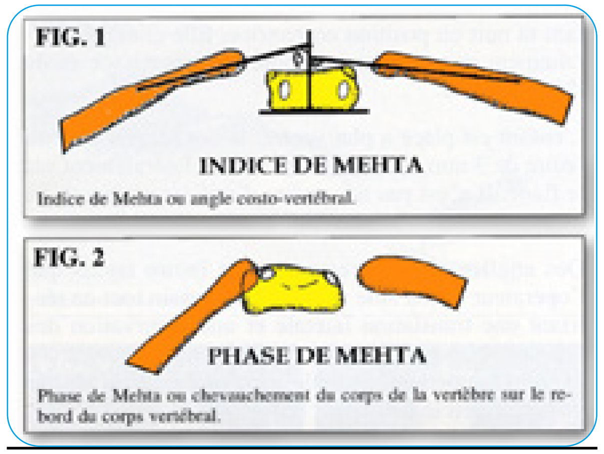


Fig 13.1 Mehta costovertebral angle

For resolving scoliosis;
- in 80% of cases, the Mehta index is less than 20° on the first radiograph;
- in 20% of cases, the index is greater than 20° and decreases three months later, even though angulation remains stable (Fig 13.2).

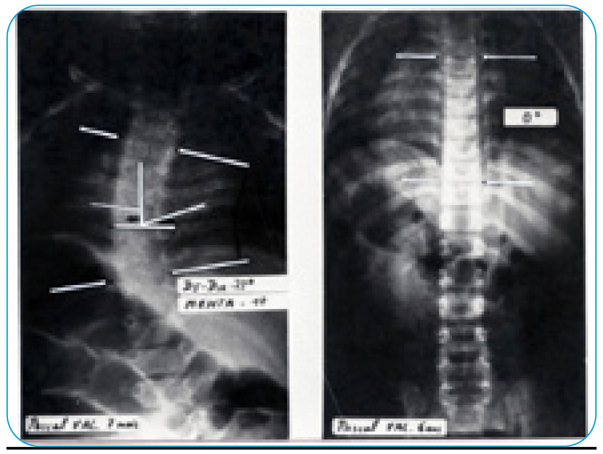

Fig 13.2 Resolutive scoliosis in newborns

For progressive scoliosis in 80% of cases, the Mehta index is greater than 20° (Fig 13.3).

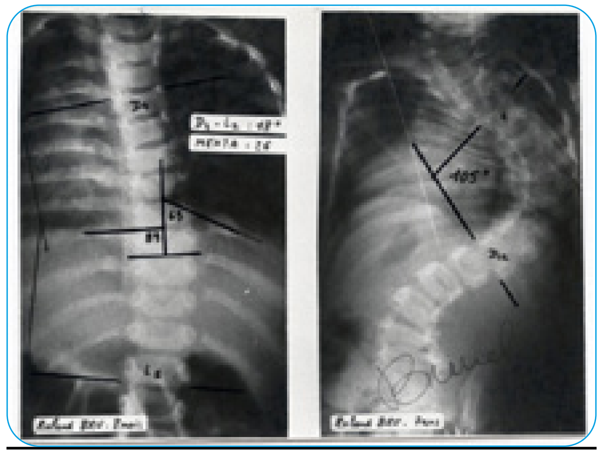

Fig 13.3 Progressive infantile scoliosis

### NOCTURNAL PLASTER SHELL TREATMENT

The nocturnal plaster cast is a technique that has been well described since the turn of the century. It involves placing the child in a corrective position at night. It is perfectly suited to the large curves of newborns and young children.

The child lies flat on its stomach, with its back covered by 3 mm of felt, which extends slightly over the child's side. A stockinette is not necessary, which will facilitate removal of the shell (Fig 13.4).

Fig 13.4 Fitting of posterior felt

Plaster splints cover the felt, while the operator and assistant stabilize the pelvis with lateral translation and shoulder flexion. When the child is small, an assistant holds the upper limbs so that the child makes a corrective arc (Fig 13.5).

Fig 13.5 Corrective inflection moulding

As soon as the plaster has set, it is removed en bloc and the correct curvature of the trunk is checked (Fig 13.6).





Fig 13.6 Cutting the plaster shell

The finishing touches are then applied while the plaster dries, with the edges of the plaster cut with an electric saw and the felt turned over and glued to the edge (Fig 13.7).

Fig 13.7 Plaster finishes

As soon as the Mehta index or phase suggests progression, treatment with a nocturnal plaster keel should be initiated (Fig 13.8).

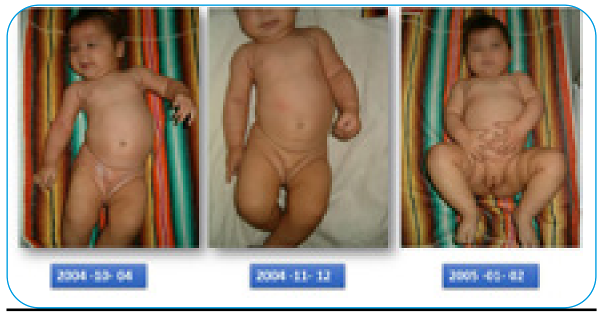

Fig 13.8 Complete correction in 3 months

# Infantile scoliosis

### HISTORY

1936; Harrenstein describes a group of 29 rachitic scoliosis. Left thoracic curves are characteristic of this group.
1951; Kleinberg describes 4 observations of young children with congenital scoliosis without neurological abnormalities.
1954; James describes 52 cases of newborns with idiopathic scoliosis.
1955; Scott and Morgan define infantile scoliosis. 1967; Wynne-Davies describes an aspect of torticollis without retraction of the sterno-cleidomatoid, and calls it plagiocephaly.
1972; Mehta describes prognostic tests for the evolution of infantile scoliosis; (Costo-vertebral angle and costo-vertebral overlap phase.
1974; Stagnara and de Mauroy describe ;
- hypotrophic infantile scoliosis,
- paradysplastic infantile scoliosis.

### DEFINITION

"Dorsal scoliosis, beginning before the age of 3, more frequent in boys, with apex on the left and a severe course" (James, 1951).
This definition takes into account only the most severe forms. There are, in fact, resolutive forms of scoliosis, and the paradox of idiopathic scoliosis must be emphasized: it can be the cause of both the most severe forms of scoliosis and those that heal spontaneously.

### FREQUENCY AND ENVIRONMENTAL FACTORS

For an identical genetic population strain, in Edinburgh 50% of idiopathic scoliosis was infantile scoliosis, in Boston 0.5% of idiopathic scoliosis was infantile scoliosis.
At the Centre des Massues between 1960 and 1970;
- 10% of idiopathic scoliosis treated was infantile scoliosis;
- 20% of idiopathic scoliosis over 100° was infantile scoliosis.
Between 1970 and 1980 ;
- 5% of idiopathic scoliosis treated was infantile scoliosis.

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Spinal Deformities in Adolescents, Adults and Older Adults.Open access peer-reviewed chapter
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Jean Claude de Mauroy, Fabio Gagliano, Rosario Gagliano and Piera Lusenti
DOI: 10.5772/intechopen.90196


## *GENERAL CONCLUSION*

*Infantile scoliosis and adult scoliosis are two totally different entities from adolescent idiopathic scoliosis. Duval-Beaupère's laws do not apply to childhood scoliosis. On the other hand, if we consider scoliosis as the translation of turbulences at the level of the spine, we can conceive that these can occur at any age where there are instability factors. Here again, the chaos theory allows us to better understand the genesis of the disease.*
*A distinction must be made between the evolution of a childhood scoliosis in adulthood, the evolutionary slope of which will be determined by check-ups every 5 years, and degenerative scoliosis with rotational dislocation. The evolution of such a scoliosis is sometimes extremely rapid with imbalances in the frontal and sagittal planes. Physiotherapy and early orthopedic treatment can in many cases relieve the patient and delay the time for surgery.*





*Chapter 14*

# 14. From anatomo-radiology to classification

**"The detailed description of the types of curve in idiopathic scoliosis in young children is important, because at present these types of curve are so frequent and present such complex and, to some extent, peculiar problems that they deserve to be treated separately..."**

**JIP James**

## Single curve scoliosis

### Lumbar scoliosis

**DEFINITION**
Lumbar scoliosis is defined by the limiting vertebrae;
- T11 or Tl2,
- L3 or L4,
and the vertebrae between L2 and L4 (Fig 14.1).

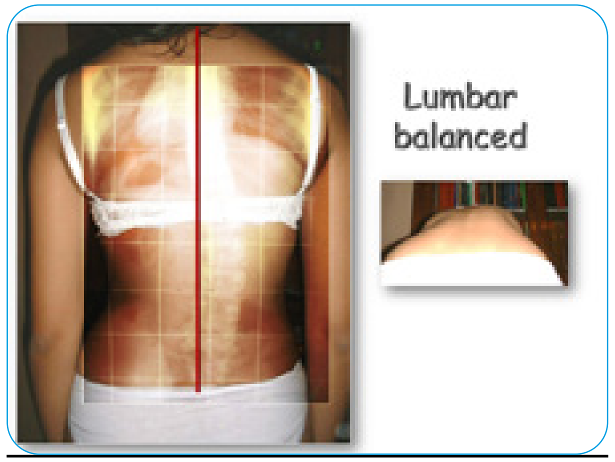



Fig 14.1 Balanced lumbar scoliosis

**CLINICAL FEATURES**
These curves are the least progressive before bone maturity, but they are the most difficult to stabilize in adulthood.
In the absence of any difference in lower limb length, lumbar scoliosis can be either convex or concave. Imbalance towards convexity is linked to the evolution of vertebral deviation (Fig 14.2).


Fig 14.2 Scoliosis unbalanced towards convexity

Imbalance towards concavity is most often due to an oblique base, either bony at the sacral plateau level, or ligamentousat the iliolumbar ligament level. Specific radiological measurements, in addition to angulation and rotation, concern the oblique base. The oblique base is studied on a radiograph in corrected lordosis. The two points at the lower end of the sacroiliac joint are determined, and the anterior-inferior bi-sacroiliac line, or BISIA, is drawn. The oblique base, corresponding to the true obliquity of the sacrum, is the angle formed by a tangent to the upper plateau of S1 and the BISlA. These two lines are parallel when there is no oblique base. The iliolumbar angle is formed by the bi-crest line and a line parallel to the lower plateau of L4 (Fig 14.3). It characterizes scoliosis with ASALIJ, as defined below.

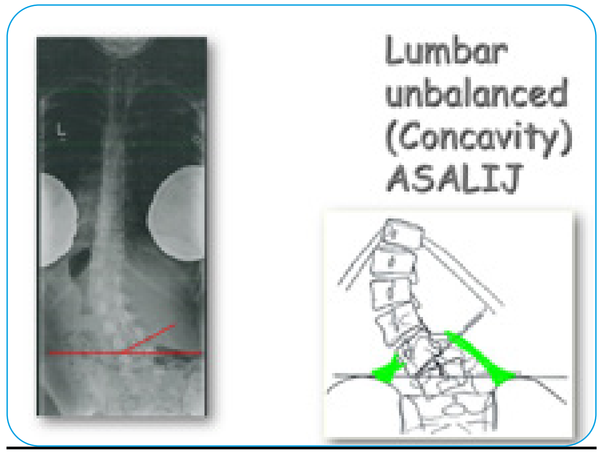



Fig 14.3 Lumbar scoliosis unbalanced towards the concavity with pelvis excluded & ASALIJ

Imbalance towards concavity is most often due to an oblique base, either bony at the sacral plateau level, or ligamentousat the iliolumbar ligament level. Specific radiological measurements, in addition to angulation and rotation, concern the oblique base. The oblique base is studied on a radiograph in corrected lordosis. The two points at the lower end of the sacroiliac joint are determined, and the anterior-inferior bi-sacroiliac line, or BISIA, is drawn. The oblique base, corresponding to the true obliquity of the sacrum, is the angle formed by a tangent to the upper plateau of S1 and the BISlA. These two lines are parallel when there is no oblique base. The iliolumbar angle is formed by the bi-crest line and a line parallel to the lower plateau of L4 (Fig 14.3). It characterizes scoliosis with ASALIJ, as defined below.

**ARTbrace PRESCRIPTION**

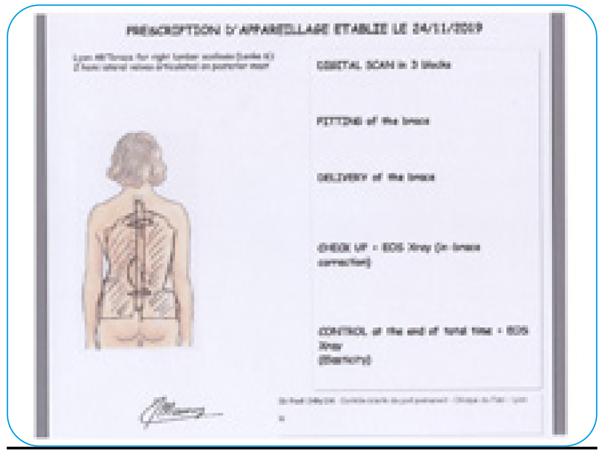



Fig 14.4 Prescription brace for right lumbar scoliosis

## *RESULTS OF TREATMENT WITH ST ETIENNE 3-POINT ELASTIC BRACE*

> **"For small changes, soft braces, and for major changes, rigid braces".**
>
> **Charles PICAULT**

71 children treated with a 3-valve elastic brace were selected on the basis of idiopathic forms, treatments carried out solely with this type of brace and according to the protocol defined above. All cases reached bone maturity (Fig 14.5).





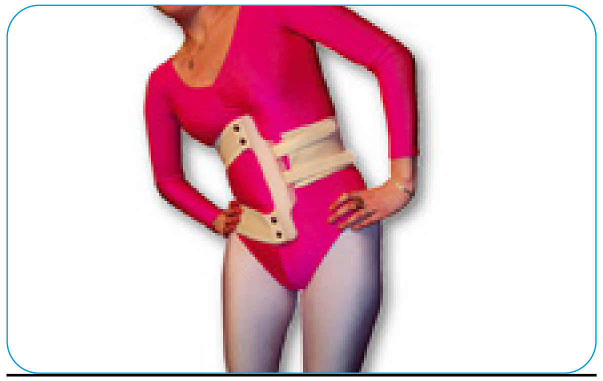


Fig 14.5 Picault 3-point brace

These were mainly girls with left lumbar curves.

The mean initial angulation at the start of treatment was 20°, and the hump 12 mm.

After 1 year of weaning, angulation was 16° and hump 8 mm .

A detailed study of the files shows that the final result is conditioned by the opening of the ilio-lumbar angle during treatment. In contrast, scoliosis angulation and rotation have no influence on the final treatment outcome.

The 3-valve elastic brace is used to slow or prevent the progression of minor lumbar structural scoliosis. Given the poor prognosis in adulthood and the benign nature of the treatment, this is a legitimate option, especially as we have developed a specific balance and probably progression test.)
The problem of the indication for early orthopedic treatment of minor curves is the most difficult to solve when the child is in front of us for consultation. We have already examined these cases with Christian Salanova. Individually, it's impossible to say whether the curve is still progressive or not, as early orthopedic treatment does not allow the curve to regress, as is usual in scoliosis, where you never go back. If we accept the chaos theory, it is illusory to control the flight of all the butterflies in Brazil in order to avoid the storm in Texas, but it always seems desirable to place a stake on the slightly twisted tree to prevent the storm from uprooting it.

## ADAPTATION OF THE PERDRIOLLE TORSIOMETER FOR LUMBAR SCOLIOSIS

The Perdriolle torsiometer has been validated for thoracic curves. The torsion angle is measured from the displacement of the convexity pedicle of the vertebra under study. To read the vertebral torsion angle, simply apply the torsiometer to the vertebral body at the vertebral apex furthest from the midline, and align the edge of the torsiometer with the edge of the vertebra under study. The median part of the vertebral body is used as a reference.

In proceeding in this way, we encountered a difficulty in measuring lumbar scoliosis in children. Indeed, the deformation of the vertebral body's bony projection is highly variable in children, with some vertebral bodies being shaped like diabolos. We therefore repeated the measurements at the lumbar level by radiographing a cadaveric lumbar spine and rotating it through a known angle. We then realized that it was possible to use the Perdriolle torsiometer by replacing the central measurement with a coincidence of 3 points on the vertebral body; 2 points at the convex ends of the upper and lower plates and one point at the end of the upper concavity plate. We checked the margin of error, which is less than 5°, as for the original method at thoracic level. This measurement is much more reliable, as it does not depend on the shape of the vertebral body (Fig 14.6).

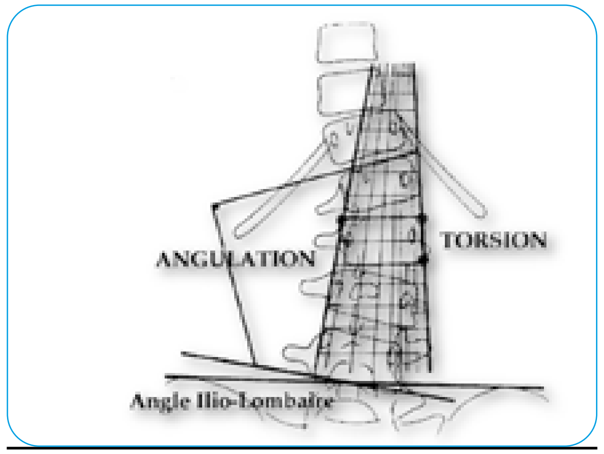



Fig 14.6 Perdriolle torsiometer for lumbar scoliosis

*Off-text illustration: Bipedalism is a fundamental element of the postural system and of epigenetics. However, thanks to tensegrity, homo sapiens can free themselves from this verticality on the ground, but also in space.*





*Chapter 16*

# 16. From bipedalism to tensegrity

> **"The human species was born when an isolated group of bipedal apes got stuck and then evolved to get a better chance of survival by eating meat."**
>
> **Richard E. Leakey**

## Bipedalism

Bipedalism and verticality are at the root of most vertebral deviations and deformities. As ontogeny reproduces phylogeny, it is important to understand how transformations from aquatic vertebrates to homo sapiens took place.

If so-called "idiopathic" scoliosis is one of the characteristics of bipedalism, it can also be observed in fish, but it is not idiopathic scoliosis. In most cases, it is a congenital malformation of the spinal column. There are also neuro-ectodermias in certain fish species, such as Recklinghausen's disease or ascorbic acid deficiency (Fig. 16.1).

When Machida induces scoliosis in rats by pinealectomy, only rats made bipedal will develop scoliosis.

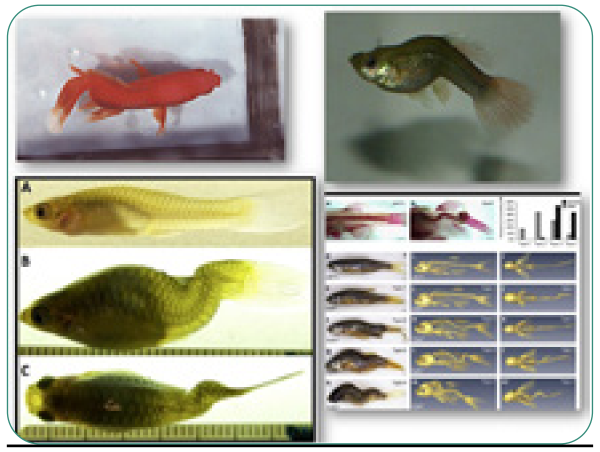


Fig 16.1 Scoliosis in bony fishes

If the functional plane of fish is the frontal plane, which enables them to move closer to the shore, that of vertebrates will become the sagittal plane when they leave the aquatic environment 450 million years ago in the Devonian period. Breathing on land requires a movement of the spine away from the ground, in the sagittal plane (Fig 16.2).

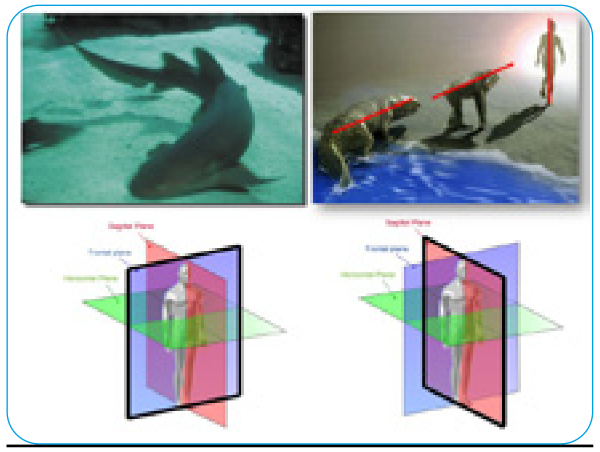


Fig 16.2 From the functional frontal plane to the sagittal plane

The newt reproduces all this evolution with vertebral movement in all planes of space. In fact, the combination of movement in the frontal plane and movement in the sagittal plane is automatically accompanied by rotation - the law of coupled movements that we use in regional moulding.
The first biped was the dinosaur Eudibamus cursoris, capable of moving at 24 km/h 300 million years ago. We'll be looking more specifically at the evolution between primates and homo sapiens (Fig 16.3).

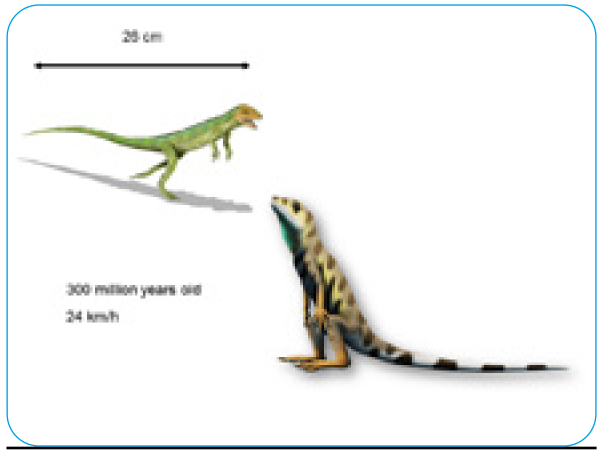



Fig 16.3 First bipedal dinosaur; Eudibamus cursoris

We will consider three approaches: paleoanthropology, genetics and ontogenetics to better understand this evolution.

## 1. Paleoanthropological approach

The australopithecine great apes gradually became more vertical. The chimpanzee is the closest genetically to homo sapiens, with a genome variation of 1%, but despite this genetic proximity, there are major differences when it comes to bipedalism (Fig 16.4).

Fig 16.4 From chimpanzee to homo sapiens

In 1974, Yves Coppens and Donald Johanson discovered one of the best-preserved australopithecine skeletons. This was not the famous "missing link", but a cousin branch of homo. The shape of the pelvis and the femur-knee angle are close to man's current bipedal position, but the scan shows that the anatomy of the semicircular canals is identical to that of chimpanzees and different from that of man (Fig 16.5).


Fig 16.5 Australopithecus Lucy

The imprint of the semicircular canals corresponds to the development of the labyrinthine vestibular system, which manages the extra-pyramidal postural system of verticality.
Changes along the vertical axis are manifold;
- Stability of lower limbs in extension.
- Anteversion of the pelvis
- Raising the center of gravity
- Lumbar and cervical lordosis
- Dissociation of girdles
- Head on gravity line
- Lateralization (Fig 16.6)

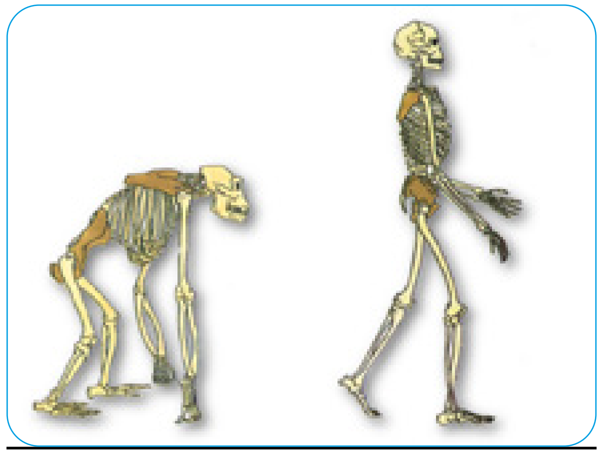


Fig 16.6 From quadrupedia to bipedal stance

A comparison between homo sapiens and the great ape shows many other differences;
- From 18 to 50 phonemes,
- Increase in brain size from less than 650 cm3 to 1.5 liters, although brain size is not a determining factor.
- Change in ribcage shape, from funnel to cone.
- The neck lengthens, as does the lumbar spine, which will promote pelvic stepping.
- Acquisition of permanent dentition is delayed to 6 years in homo sapiens
- Longevity increases from age 40 to over 70
- Finally, homo sapiens is the only species to have pubertal growth (Fig 16.7).



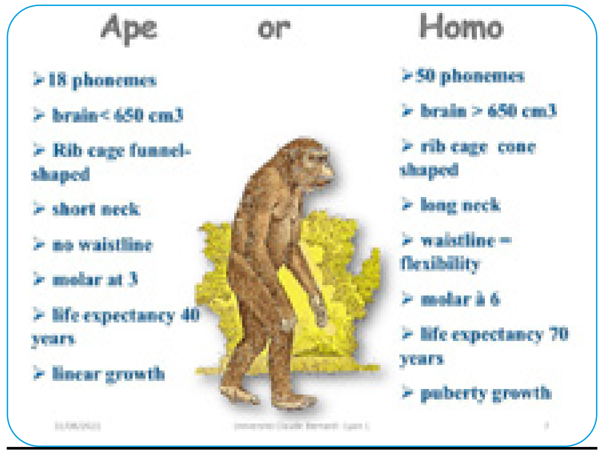


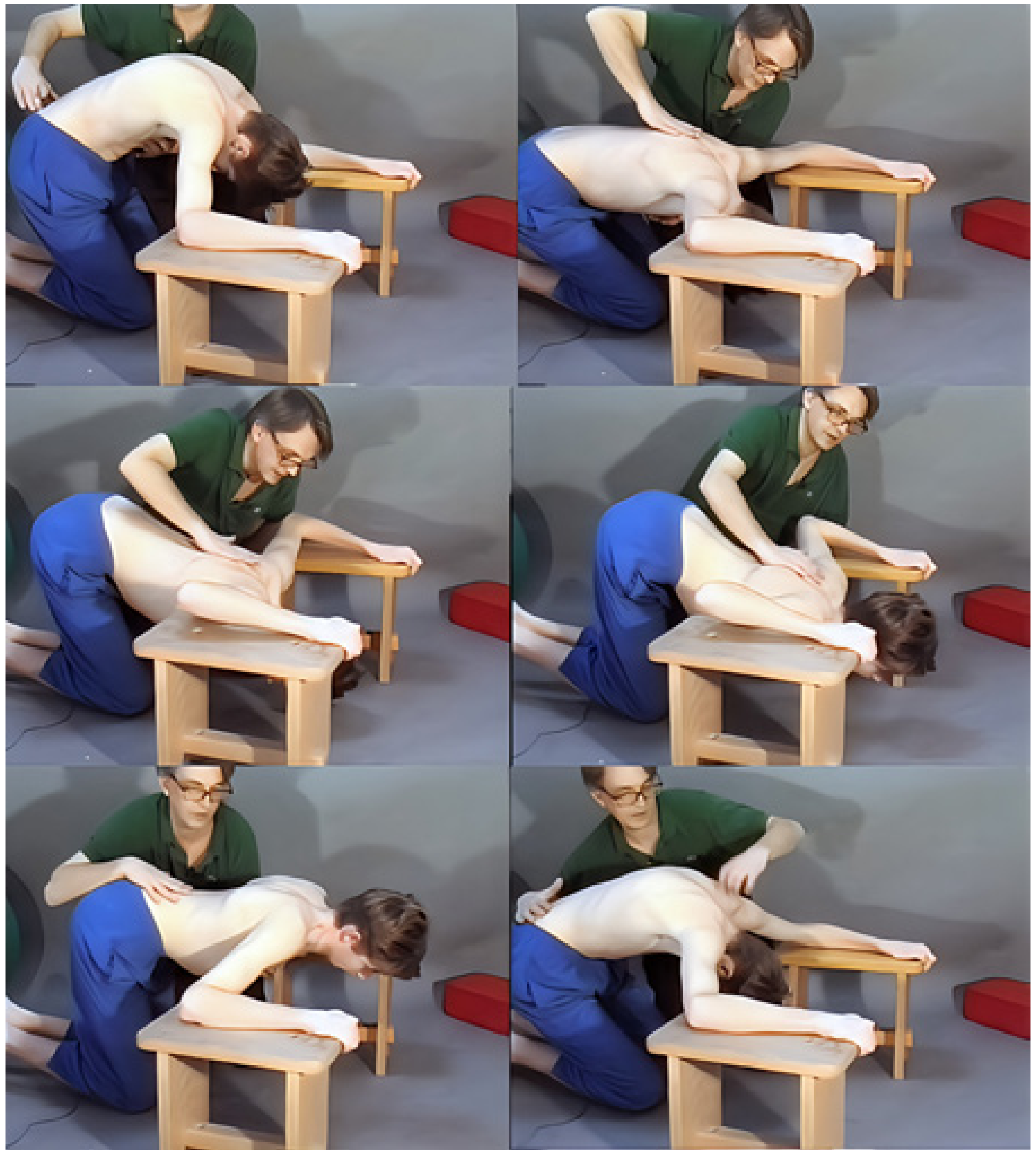

Fig 16.7 Changes induced by standing

The major advantage of bipedalism is that it frees up the upper limbs for movement. This is an advantage for hunting and, more generally, for tool use. Communication via the upper limbs becomes possible, as does writing.
It was probably not the transformation of the forest into savannah that led australopithecines to straighten up, as Coppens thought.
As for the radiator theory, it's true that bipedalism consumes energy, but the sweating system makes it possible to perform this function.
We will consider all anatomical modifications from head to toe.

## Orthopedic modifications

### *FEET*

The first traces of bipedal footprints discovered by Mary Leakey in the ashes of the Laetoli volcano in Tanzania date back 4 million years. Walking is done with the feet close together. The trunk rotates more freely, so that the center of gravity passes through the middle of the knee.
Footprints include the main features of the homo sapiens foot;
- Bringing the big toe closer to the axis of the foot.
- In addition to the transverse curve found in chimpanzees, a longitudinal curve appears on the first radius (Fig 16.8).



*Off-text illustration: The steam locomotive's quadrupedal exercise performs a ballistic stretching typical of the Lyon Method for correcting Hyperkyphosis.*





*Chapter 17*

# 17. From spondylolisthesis to kyphosis: sagittal deviations

> **«When you carry your friends, no one becomes a hunch-back.»**
>
> **English proverb**

## Spondylolisthesis

Twenty percent of lumbar scoliosis is associated with spondylolysis or spondylolisthesis, complicating treatment.

### DEFINITIONS

Spondylolisthesis, from the Greek "spondylo" meaning vertebra and "olisthesis" meaning slippage, is a deviation of the spinal column generally located at the lumbosacral level. On the borderline between traumatology and orthopedics, it poses numerous problems to which orthopedic medicine can provide solutions. Spondylolisthesis is a vertebral pathology characterized by the sliding of a vertebra forward or backward of the underlying vertebra. The vertebrae most frequently affected are the fifth and fourth lumbar vertebrae.
Abnormal mobilization of the vertebral body is made possible by a lesion known as spondylolysis. This is a loss of bone continuity at the level of the vertebral articular isthmus, which is the area defined as the junction between the upper and lower joints of the vertebra's posterior arch (Fig 17.1).

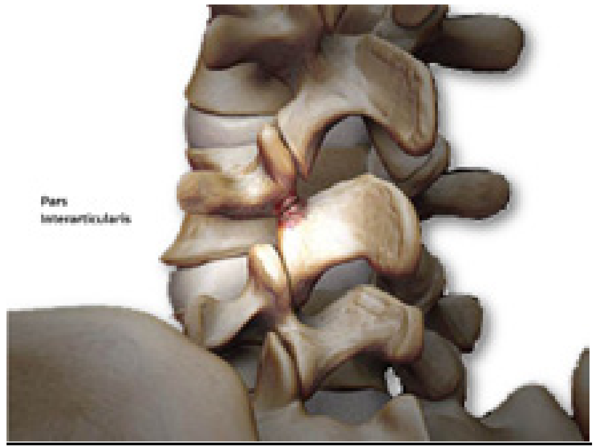



Fig 17.1 Pars Interarticularis

When spondylolysis affects both vertebral isthmuses, the body of the vertebra is completely detached from the posterior arch. The trunk is then disconnected from the pelvis and lower limbs.
Spondylolysis can be acute or chronic. The acute form is traumatic, with a true bifocal vertebral fracture, and its healing potential is greatest when displacement is minimal and diagnosis and treatment are made. In the chronic form, there is progressive stretching of the isthmus, followed by rupture of the isthmus and the formation of pseudo-fibrous tissue or sometimes a cyst.
The incidence of spondylolysis in the general population is between 3% and 7%. The incidence in athletes is higher, between 20 and 40%.

Spondyloptosis is the final stage of spondylolysis, with lumbosacral dislocation and the last lumbar vertebra falling into the pelvis (Fig 17.2).

Fig 17.2 Spondyloptosis

## Anatomy

The fracture is located at the pars interarticularis level between the two facet joints and in front of the lamina.
The upper facet is subjected to forward sliding stresses. The lower facet is subjected to upward and rearward sliding stresses (Fig 17.3).

Fig 17.3 Fracture of the pars interarticularis

## Genetics

Fractures of the posterior arch of L5 are very common in Homo sapiens, although there are differences depending on the origin of the population. It is very common (30-60%) among the Inuit, who have a specific genetic sequence that enables them to withstand the cold (Denisova man).

Spondylolysis affects 5 to 7% of the Caucasian population.
The epidemiology of this condition was well defined by Rossi in 1995. It does not exist at the moment of birth, but bone fragility factors, generally minor forms of spina bifida, favor slippage (Fig 17.4).

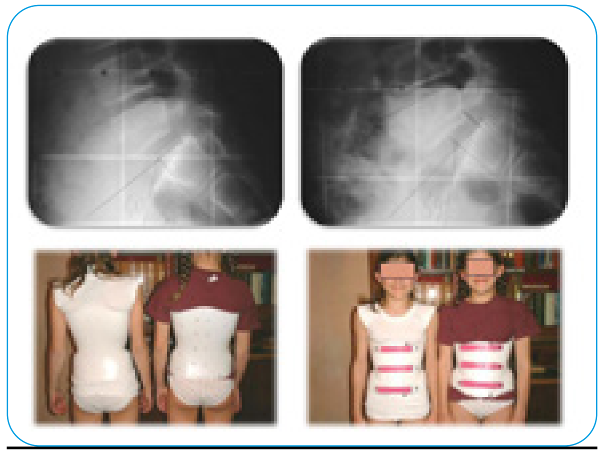


Fig 17.4 Twins

The mode of transmission is dominant with reduced penetrance. It affects 25% of athletes. Localization is L5 in 95% of cases and bilateral in 95% of cases (Fig 17.5).

Fig 17.5 spina bifida

Spondylolisthesis is an acquired phenomenon following verticalization. The isthmus is fusible, but the fatigue fracture is unique in that it is hereditarily predisposed, painless in most cases, lacks periosteal callus and consolidates spontaneously. Two forms can be described: Vertical and horizontal sacrum.





## Biomechanics

Biomechanically, the sliding component increases with the angulation of the sacral slope. The elasticity of the ligaments and sporting activity in hyper-extension will promote progressive slippage during growth (Fig 17.6).

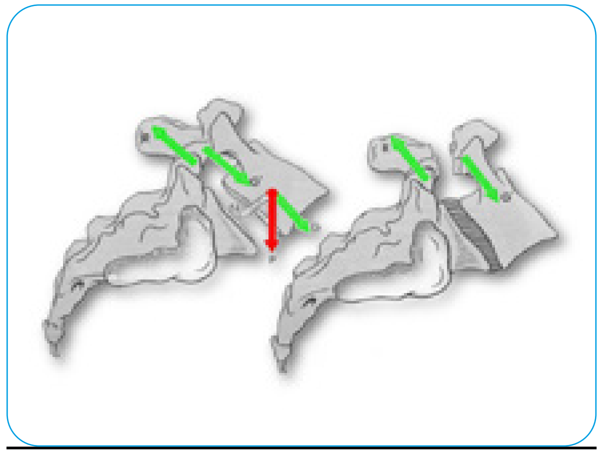


Fig 17.6 Biomechanical components

Spondylolisthesis does not occur at birth, but bone fragility factors, usually minor forms of spina bifida, favor slippage.
Micro-traumatic factors such as hyperextension and load stress are responsible for the fracture.
Radiologically, the ¾ image allows better visualization of the pars interarticularis when lysis is of the faint fissure type.

### *Progressive onset spondylolysis;*

The onset of spondylolisthesis is linked to genetic and mechanical factors. Indeed, the onset of trunk slippage is directly linked to verticalization and gravitational contractions, as spondylolisthesis is never found in children who have been unable to verticalize for neuromuscular reasons (Fig 17.7).

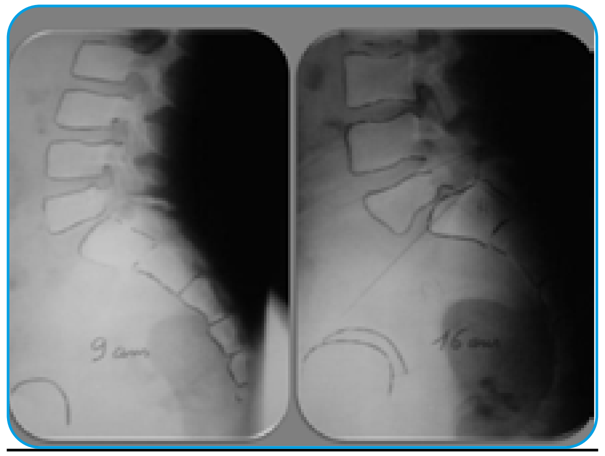


Fig 17.7 Progression through puberty

The posterior arch of L5 is usually hypoplastic, with occasional closure defects at the level of the posterior spinous process. These spina bifida occulta weaken the structure of the posterior paravertebral ligament.
In 95% of cases, isthmic lysis is located at L5, although it may be at L4 in children involved in rhythmic gymnastics and sports.
The morphotype with excessive inclination of the sacral slope accentuates the sliding component of the L5 vertebra. This morphotype may result either from an incorrect pelvis anteversion attitude and hyperlordosis, or from a high Duval-Beaupère lumbopelvic incidence.

### *Traumatic spondylolysis*

Acute spondylolysis following a violent shock is rare; more often than not, it involves repeated microtrauma, the process of which is identical to that of a fatigue fracture. The "cigar cut" mechanism was described by Roy Camille during hyperlordotic movements; the isthmus of L5 is in fact pincered during hyperlordosis between the inferior articular process of L4 and the superior articular process of S1, which would explain a higher prevalence of 22 to 43% in top-level athletes according to Rossi.

## Natural history of spondylolisthesis

It was described by Maldague in 1985 [3] on the basis of radiographs.
1. Condensation of a pedicle.
2. Unilateral lysis of a pedicle, sometimes with scoliosis formation.

pain, especially if the kyphosis is rigid.
The biomechanical basis of conservative treatment is to reduce mechanical stress on the anterior wall of the vertebral body.
The main indications for early treatment are stiffness, curve size and Cobb angle.
The best time is at the start of puberty. The brace should be worn for around 2 years and removed at the end of growth without skeletal maturity at Risser 5.
For thoracic kyphosis, the brace must be worn all night and part of the day. The most appropriate brace is a 4-point system, or a 5-point system in the case of muscular imbalance.
For thoraco-lumbar kyphosis, the brace must be worn during the day in a seated position, and the ideal brace is a 4-point system.
For juvenile kyphosis, the brace should be worn part-time, and the ideal brace is the Milwaukee.

## CONCLUSION

Physiotherapy and, more generally, orthopedic management of kyphosis is not as well known as that of scoliosis, since the respiratory consequences of kyphosis are less incapacitating. As the population ages, kyphosis often becomes a major problem because of the pain and imbalance involved in standing and walking. Loss of autonomy becomes crucial, and it is often too late to treat effectively. Management must be effective in adolescence: there is no "light"treatment for kyphosis. In adult cases, treatment is more a matter of lifestyle and workstation adaptation, which makes it very difficult to prove the efficacy of physiotherapy. Results are better with conservative orthopedic treatment, and the retrospective study is encouraging. Long-term prospective studies should confirm the value of these treatments, as in regular kyphosis, the risk of neurological surgery is greater than in scoliosis, due to the risk of stretching the artery of Adamkievitz.

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Jean Claude de Mauroy

SOSORT Pre-Meeting 2017
THE SAGITTAL PROFILE
by the Education Committee






*Chapter 18*

# 18. From scoliosis to mathematics

**"When there is beauty in character, there is harmony in the home. When there is harmony in the home, there is order in the nation. When there is order in the nation, there is peace in the world."**

**A. P. J. Abdul Kalam**

## Introduction

Some of the concepts specific to the Lyon Method, such as solid geometry, isostatic harmony and balance, chaotic scoliosis and tensegrity, will be explained in this chapter.
Scoliosis is undoubtedly the area of medicine where measurements are the most numerous. They are fundamental for assessment, therapeutic indication and evaluation of results.
We live in a three-dimensional space, and scoliosis is a three-dimensional deformity. In mathematics, dimensions are the measure of the size or distance of an object, region or space in one direction. In simpler terms, it's the measurement of an object's length, width and height (Fig 18.1).

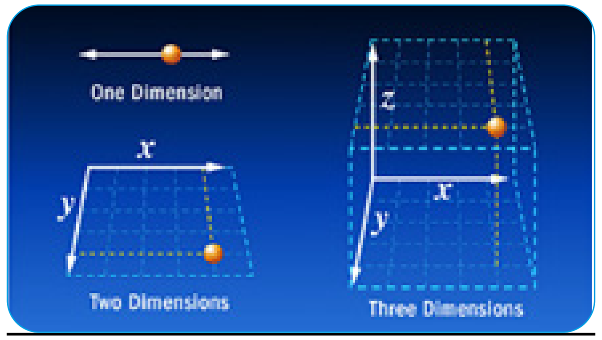



Fig 18.1 The 3 dimensions of our space

**Solid geometry**
Unfortunately, scoliosis is usually described using 2-dimensional plane geometry, such as the Cobb angle. This plane geometry is a false 3D, like a shadow of the true deformity.
Scoliosis is mathematically a torso column, i.e. a helix with a horizontal generating circle. Helicoidal motion is performed by a part or object moving along a fixed axis, rotating around it. Rotational and translational movements are combined. Detorsion correction is therefore much more logical than the combination of frontal deflection and horizontal derotation, not to mention correction in the sagittal plane (Fig 18.2).

Fig 18.2 Scoliosis is a circled helicoid

**Plane geometry**, even in the 3 arbitrary planes of space, is an image that doesn't make it easy for our brains to reconstruct volume.
This is why the Lyon Method, since the advent of EOS and volumetric moulding, prefers to use solid geometry. Vocabulary changes with the volumetric concept.
Today, horizontal derotation is replaced by detorsion.
Axial self-elongation becomes geometrical detorsion.
The concept of mechanical detorsion is linked to coupled movements of the spine. The combination of sagittal isostatic balance, frontal correction by flexion or displacement, and the bringing of vertebral bodies closer to the vertebral axis by the "mayonnaise tube effect" automatically generates mechanical detorsion.

The description of the object in our three-dimensional space precedes the measurement stage (Fig 18.3-4).

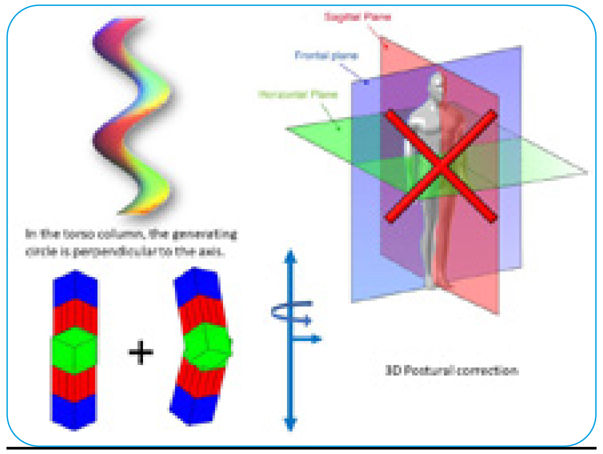



Fig 18.3 Detorsion is a true three-dimensional correction

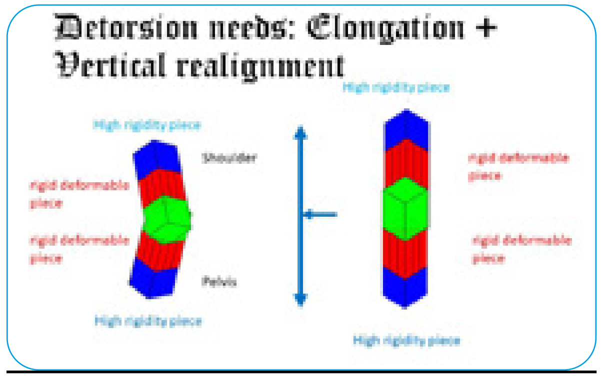



Fig 18.4 Geometrical and mechanical detorsion

## The numbers of harmony

These measurements are made using numbers. As mathematics developed, so did civilizations. 6000 years ago, the Sumerian civilization left us numerous traces of these calculations on clay tablets (Fig 18.5).

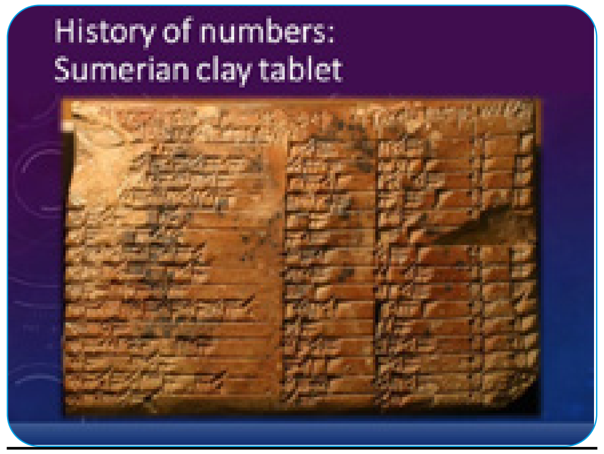



Fig 18.5 Sumerian numeration

A sedentary lifestyle with crops and livestock requires calculations of surface area, livestock and grain storage....
The Sumerians used base 60, as 60 is the smallest integer that admits 12 divisors (like hours and months) (Fig 18.6).

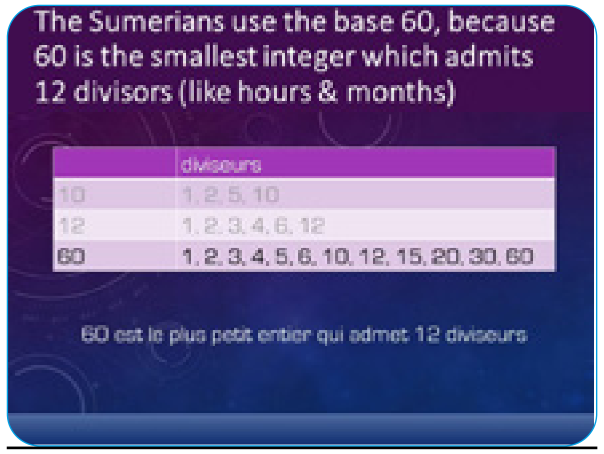



Fig 18.6 Sumerian base 60

Sumerian numbering is positional, like ours, with the use of specific symbols, mainly the nail and the chevron. The unit of measurement for scoliosis angulation in Cobb degrees dates from this period (Fig. 18.7).





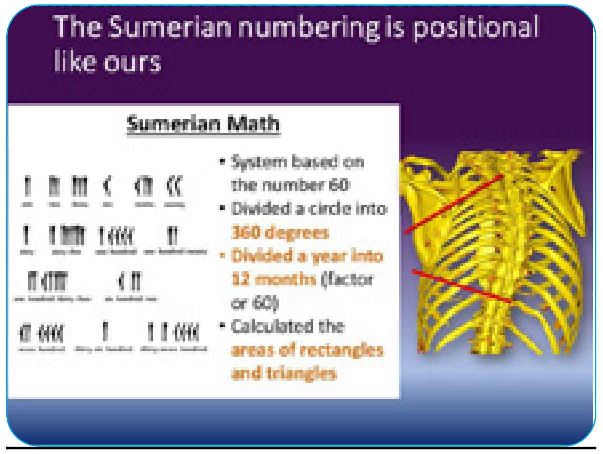



Fig 18.7 Using Cobb; Sumerian numbering

The Sumerians invented the separator. The Sumerians didn't know the zero we owe to the Mayans, but they used the separator to indicate the absence of a symbol.
Many astronomical data are the simplest in base 60, such as the hour and its derivatives minutes and seconds.

4600 years ago, 1500 years before the Bronze Age in Europe, the Egyptians used the base 10, which was used to build the Keops pyramid. They also knew the meter, the π and Φ (Fig 18.8).


Fig 18.8 Egyptian Base 10

The key to the Great Pyramid is Φ or or golden number, which corresponds to a kind of Harmony of measures in the 3 planes of space.
In a plane of dimension 1, Φ is a very specific length ratio between a and b. a+b is to a as a is to b. This means that a+b divided by a = a divided by b. The result of this equation is Φ or 1.618 or 1 + root of 5 divided by 2 (Fig 18.9).

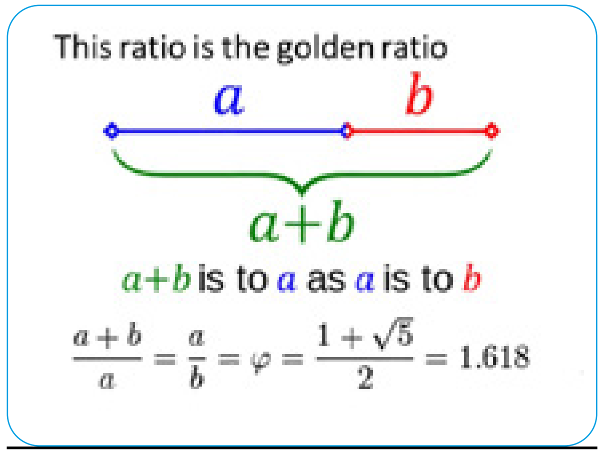



Fig 18.9 Definition of the golden ratio

Φ is an irrational number; this means that phi is not the quotient of an integer. It corresponds to a second-degree equation (Fig 18.10).

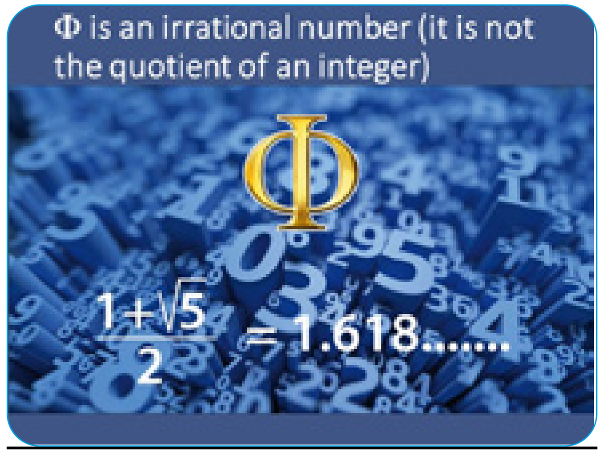
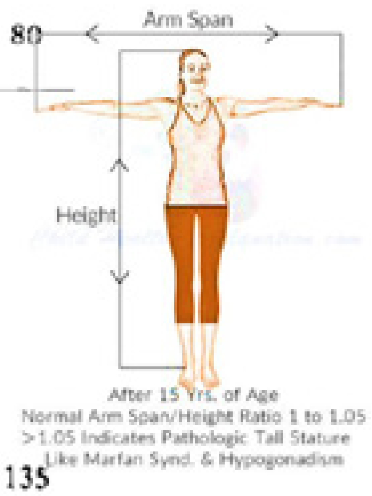



Fig 18.10 Second-degree equation

Φ has a unique characteristic. Φ + 1 = square of Φ. Φ minus 1 = inverse of Φ. This relationship is unique. This is why Φ is called the golden number (Fig 18.11).

| AS \ A | 5 | 10 | 20 | 40 | 60 | 80 |
|---|---|---|---|---|---|---|
| Males | | | | | | |
| 100 | 102 | 101 | | | | |
| 105 | 106 | 106 | | | | |
| 110 | 111 | 111 | | | | |
| 115 | 116 | 115 | 115 | | | |
| 120 | 120 | 120 | 119 | | | |
| 125 | 125 | 125 | 124 | | | |
| 130 | 130 | 129 | 129 | | | |
| 135 | 134 | 134 | 133 | | | |
| 140 | 139 | 139 | 138 | | | |
| 145 | 144 | 143 | 143 | 141 | 140 | 138 |
| 150 | 148 | 148 | 147 | 146 | 144 | 143 |
| 155 | 153 | 153 | 152 | 150 | 149 | 148 |
| 160 | 158 | 157 | 156 | 155 | 154 | 152 |
| 165 | 162 | 162 | 161 | 160 | 158 | 157 |
| 170 | 167 | 167 | 166 | 164 | 163 | 162 |
| 175 | | 171 | 170 | 169 | 168 | 166 |
| 180 | | 176 | 175 | 174 | 172 | 171 |
| 185 | | 181 | 180 | 178 | 177 | 176 |
| 190 | | 185 | 184 | 183 | 182 | 180 |
| 195 | | 190 | 189 | 188 | 186 | 185 |
| 200 | | | 194 | 192 | 191 | 190 |

| AS \ A | 5 | 10 | 20 | 40 | 60 | 80 |
|---|---|---|---|---|---|---|
| Females | | | | | | |
| 100 | 104 | 103 | | | | |
| 105 | 108 | 108 | | | | |
| 110 | 113 | 112 | 112 | | | |
| 115 | 118 | 117 | 116 | | | |
| 120 | 122 | 122 | 121 | | | |
| 125 | 127 | 127 | 126 | | | |
| 130 | 132 | 131 | 130 | | | |
| 135 | 136 | 136 | 135 | | | |
| 140 | 141 | 141 | 140 | 138 | 136 | 135 |
| 145 | 146 | 145 | 145 | 143 | 141 | 139 |
| 150 | 151 | 150 | 149 | 148 | 146 | 144 |
| 155 | 155 | 155 | 154 | 152 | 151 | 149 |
| 160 | 160 | 160 | 159 | 157 | 155 | 154 |
| 165 | | 164 | 163 | 162 | 160 | 158 |
| 170 | | 169 | 168 | 166 | 165 | 163 |
| 175 | | 174 | 173 | 171 | 169 | 168 |
| 180 | | 178 | 177 | 176 | 174 | 172 |








*Chapter 19*

# 19. From the Lyon Method to others

**"Stay in active learning. You need to learn, research and be passionate about new ways and methods of doing things to be and stay relevant."**

**Martin Luther King**

## Chronology of methods

All methods are irrigated by an identical sap that constitutes a consensus. This consensus, developed within SOSORT, constitutes the guidelines for the conservative treatment of scoliosis. As far as exercises are concerned, the consensus is very limited. Technically, all the methods agree only on 3D self-correction, but how is this 3D self-correction to be achieved? The concept is very different for the Lyon Method and the Schroth method. To make physiotherapy easier to understand, we can compare the two historical methods, the Lyon Method and the original Schroth (Fig. 19.1).

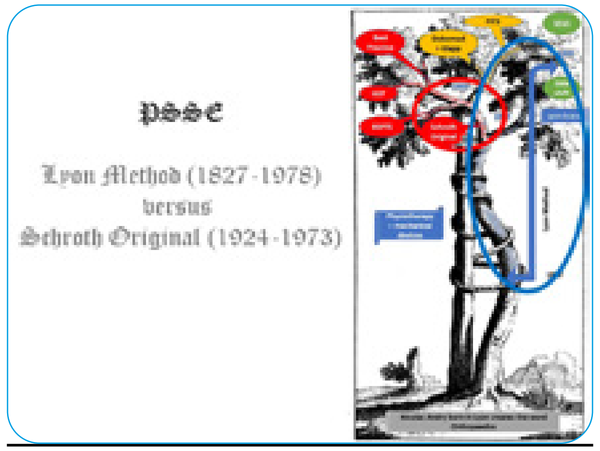



Fig 19.1 Chronology of validated methods

All methods have their origins in Chinese kung fu. In the mid-17th century, Father Jean Joseph Marie Amiot arrived in Beijing. He was personally welcomed by Emperor Kien Long. Through his research published in "Kong fu", he was the unwitting and little-known creator of Swedish gymnastics. It was he who introduced this practice to Europe, and it was also practiced at the court of Louis XV (Fig 19.2).

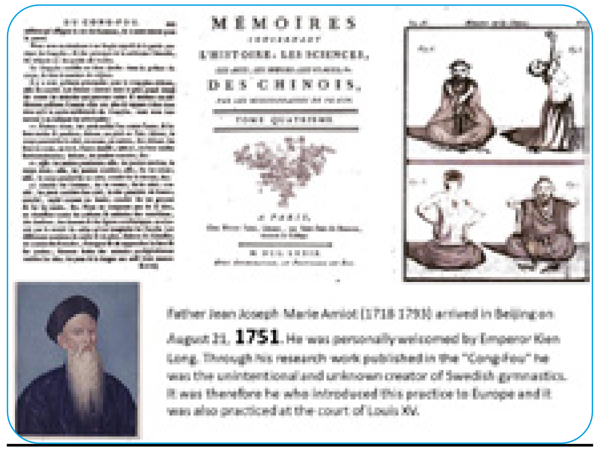



Fig 19.2 Kong fu is the origin of all methods

Pier Henrik Ling: the father of Swedish gymnastics

In fact, Chinese kung fu served as the basis for the Swedish gymnastics widely used from Ling to Strockolm in the early 19th century (Fig 19.3).

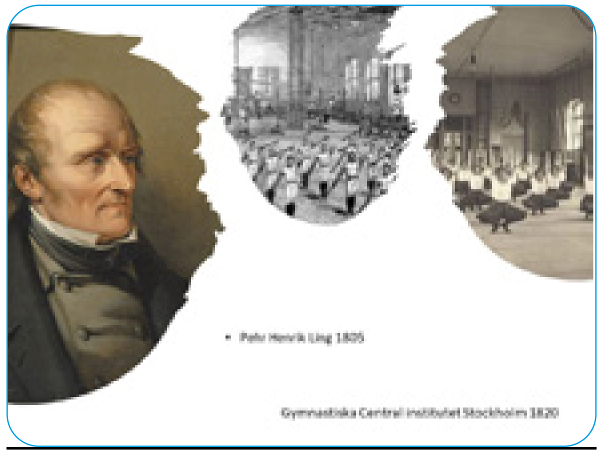



Fig 19.3 Pier Henrik Ling: The father of Swedish gymnastics

For over a century, calisthenics has been adapted to various pathologies, including scoliosis (Fig 19.4).

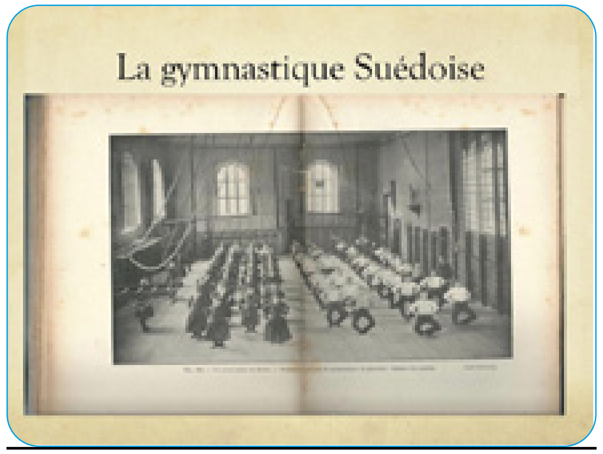



Fig 19.4 Calisthenics spreads throughout Europe

The Lyon Method is based on advances in the physiology of the postural system. In 1824, a French physiologist, Jean Pierre Flourens, published his first work on pigeon scoliosis after destruction of the labyrinth, although he had expected simple deafness. This was the first experiment on the postural system (Fig 19.5).

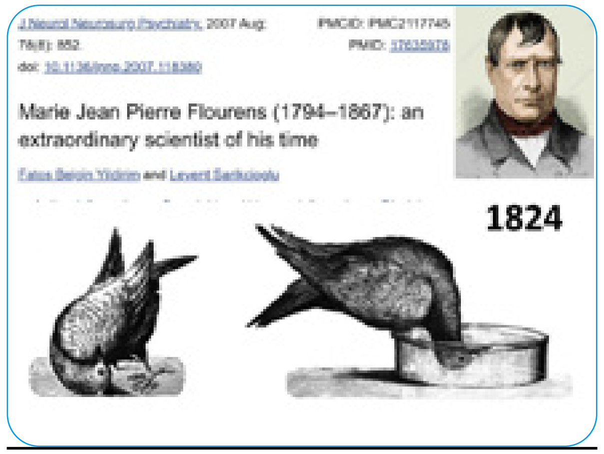



Fig 19.5 Flourens experiment: the scoliotic pigeon

## Lyon vs Schroth

In France, Pravaz describes in his book the "orthopedic swing" or tilting tray designed to stimulate what will become the vestibulo-labyrinthic sensor and the vestibulospinal tract of the extrapyramidal system. Note that the patient's position is very close to the Schroth corrective position (Fig 19.6).

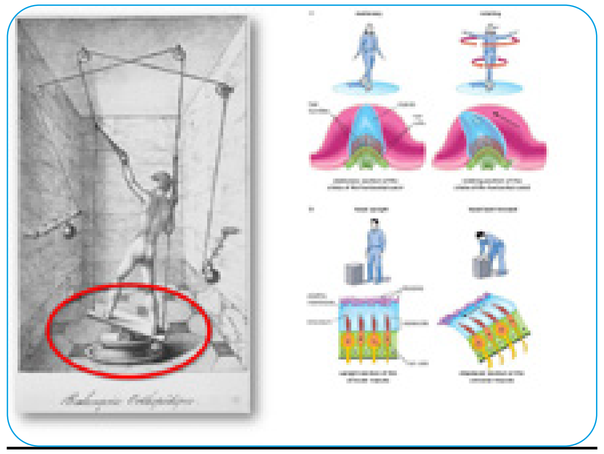


Fig 19.6 Pravaz and the orthopedic swing

In Germany, at the beginning of the 19th century, Jahn is considered the father of this type of gymnastics, and Oldevig's first publication in 1913 describes the adaptation of these exercises to scoliosis (Fig 19.7).





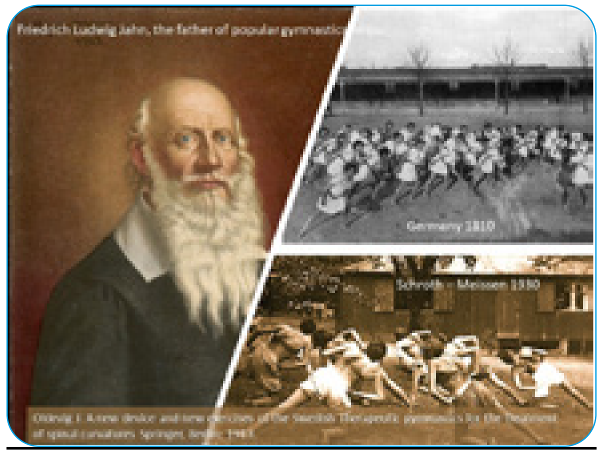



Fig 19.7 Asymmetrical gymnastics in Germany

**Charles Gabriel Pravaz**, a physician and engineer, and Katharina Schroth are the founders of the two main methods. The latter was 19 when Oldevig's book was published. She herself suffered from moderate scoliosis and underwent treatment with a steel brace at the age of 16. During the first decade of her professional career, Katharina Schroth trained at a gymnastics school to be able to treat patients herself without a brace (Fig 19.8).


Fig 19.8 Pravaz and Schroth

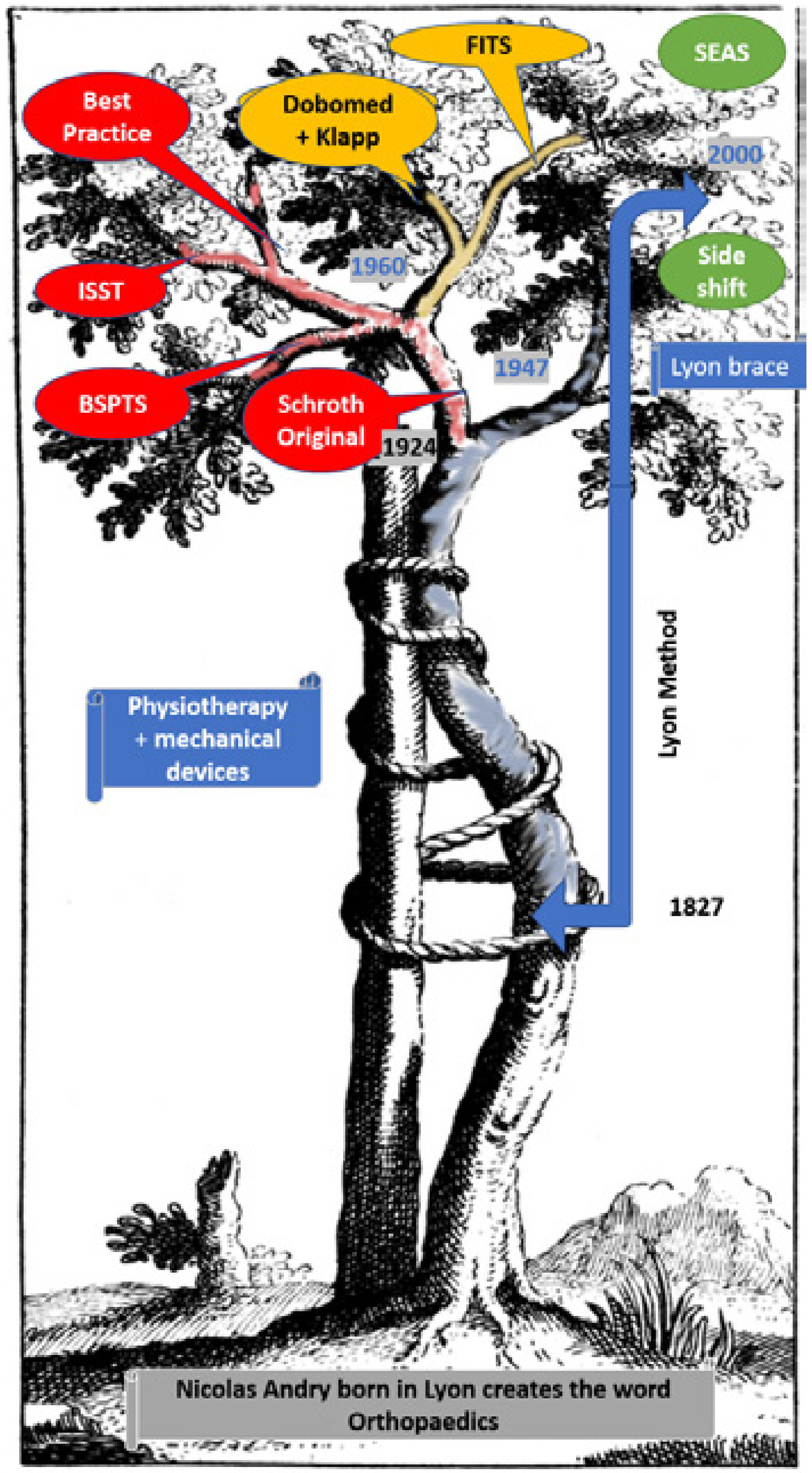
The history of the two methods provides a better understanding of the corrective approach. The first publications on the Lyon Method date back almost 200 years. 100 years later, Katherina Schroth's publications focus on breathing. The title of Pravaz's book concerns a new method for treating spinal deviations. Katherina Schroth's publications do not yet constitute a method (19.9).


Fig 19.9 Original publications

The last book on the Lyon Method was published in 1978. Christa Lehnert Schroth's 1973 book is a truly original method of treating scoliosis, explaining the concept of three-dimensional correction.
The book "Rééducation de la scoliose" is a synthesis intended for students at physiotherapy schools in France. It covers the 12 basic exercises of the Lyon Method and how to use them. Christa Lehnert Schroth's book explains the three-dimensional block correction of scoliosis (Fig 19.10).


Fig 19.10 Latest publications

The Lyon Method evolved steadily over 200 years, stabilizing with the creation of the physiotherapy specialty. The Lyon physiotherapy school was integrated into the Faculty of Medicine under the direction of Pierre Stagnara.
The Schroth Method is currently taught by 3 schools in Germany and Barcelona. The Lyon








*Chapter 20*

# 20. From myths to misconceptions

**Myths are public dreams, dreams are private myths.**

**Joseph Campbell**

## Separate the 21 myths from the facts.

All specialists in scoliosis and its treatment are confronted almost daily with a number of myths and misconceptions. People often come confused and frightened by this condition, and the research they've done usually contains as many falsehoods as truths (Fig 20.1).


Fig 20. 1 Introduction

### *#1 - "Scoliosis screening doesn't help sufferers".*

Current policy in English-speaking countries does not support mass screening due to cost, the potential for false positives, the belief that braces don't work and that if the curve is severe enough, the family or other adults will notice.

The earlier it is detected, the more likely it is that the right treatment can be administered at the right time.

At the screening stage, scoliosis is chaotic, in a context of delayed maturation of the postural system. It is therefore impossible to predict the eventual transition to linear scoliosis, and only regular observation of the signs of transition to linear evolution can enable early treatment at a small angle. The Lyon Method of physiotherapy focuses on stimulating the extrapyramidal postural system (Fig 20.2).

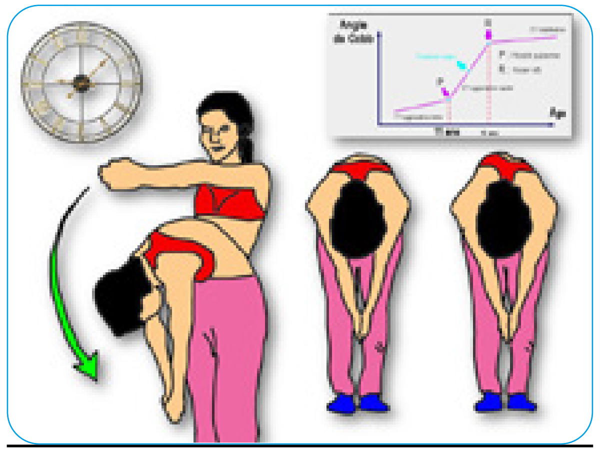


Fig 20..2 Essential Adams test

### *#2 - "Scoliosis is caused by poor posture".*

Poor posture is never the cause of scoliosis. Major asymmetries such as infantile hemiplegia rarely cause structural scoliosis. On the other hand, rowers on Roman galleys regularly changed sides, and habitual poor posture, including in the sagittal plane, considerably increases the frequency of scoliosis. In all cases, children should be taught the correct sitting and writing position (Fig 20.3).

Fig 20.3 Don't confuse position with posture

### #3 "Scoliosis can be caused by carrying heavy backpacks".

If the weight of the schoolbag exceeds 25% of body weight, lumbar pain becomes much more frequent, but not scoliosis, which increases the resistance of the spinal column. On the other hand, if the load is prolonged over time, it can contribute to an increase in growth asymmetry of the apical vertebrae. It is advisable to teach the child to position the load correctly, with the heaviest books, for example, in contact with the back (Fig 20.4).

Fig 20..4 The schoolbag does not cause scoliosis

### #4 - "Scoliosis can be corrected by simply sitting up straight".

More than half of progressive linear scoliosis, often the most severe, is accompanied by a flat back. An arched sitting position is therefore to be preferred to one that is too upright. The most important thing is to offer the brain 3 points of contact: the two forearms on the work surface and the base of the thorax on the front edge of the work surface (Fig 20.5).

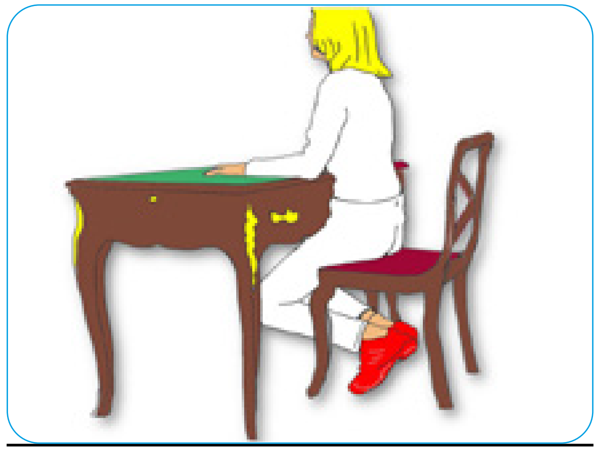


Fig 20.5 Writing seated position

### #5 - "Scoliosis is preventable".

The unpredictability of chaotic scoliosis greatly limits prevention. In a chaotic system, even if the snowflake triggering the avalanche were known and could be eliminated, another would take its place. You don't go butterfly hunting in Brazil to avoid a storm in Texas. Even if we know that dental deformities are more frequent in cases of scoliosis, fitting a bit is not a preventive treatment for scoliosis. The same applies to insoles (Fig 20.6).





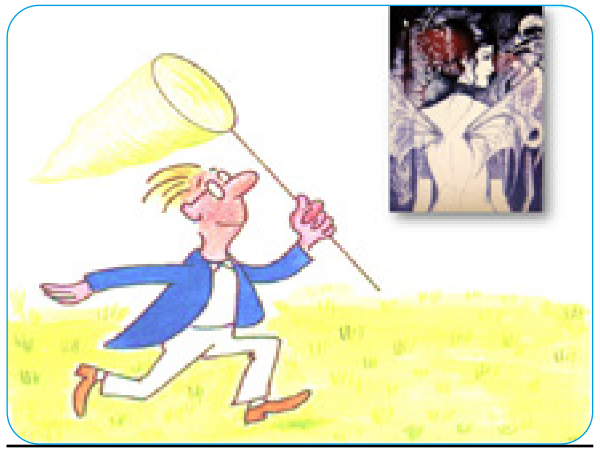


Fig 20.6 chaotic = difficult to prevent

### #6 "Scoliosis only develops in adolescence".

While it's true that the majority of scoliosis develops during the pubertal period, we mustn't overlook infantile and juvenile scoliosis, which will evolve over many years, posing problems of thoracic deformation with braces, and psychologically in terms of treatment duration. In fact, the highest incidence of scoliosis occurs after the age of 65, with almost 10% of the population affected (Fig. 20.7).

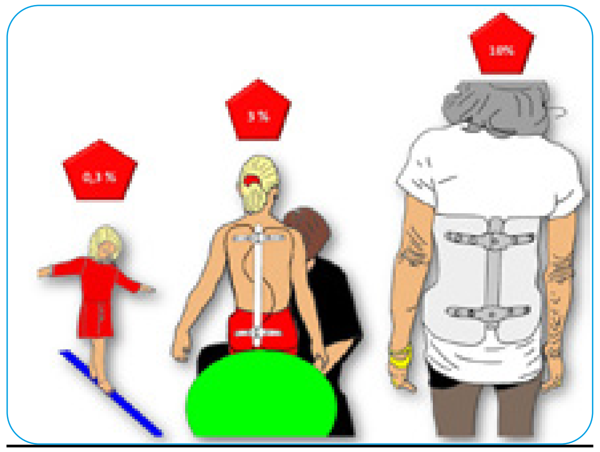


Fig 20.7 Prevalence increases with age

### #7 - "Anyone diagnosed with scoliosis will end up with a severe deformity".

While some cases of scoliosis result in severe deformity, the vast majority do not.
This myth is often used to justify early surgery. The average natural history of scoliosis in adulthood should not be confused with a linear equation over time. In fact, the evolution of scoliosis in adulthood is far from linear. With Lyon's conservative treatment including plastic deformation time, we have shown that the natural history of scoliosis is significantly slowed in adulthood (Fig 20.8).

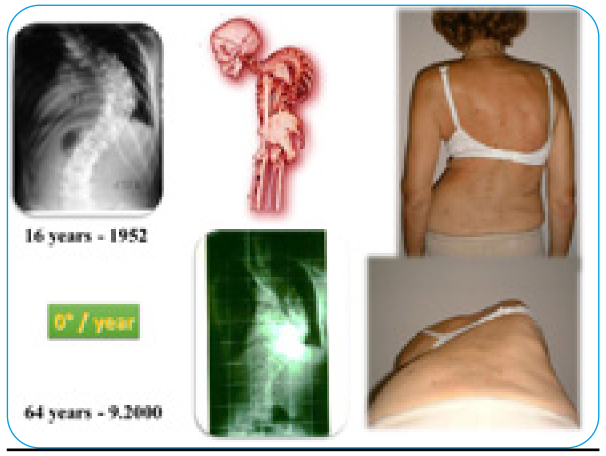



Fig 20.8 Stability of certain scoliosis

### #8 - "Scoliosis only affects girls".

Maturation of the postural system occurs on average at the age of 12. Pubertal growth begins at age 11 in girls, before postural maturation, which explains the greater frequency of scoliosis in girls. The onset of pubertal growth in boys occurs around the age of 13, on a more mature postural system (Fig 20.9).

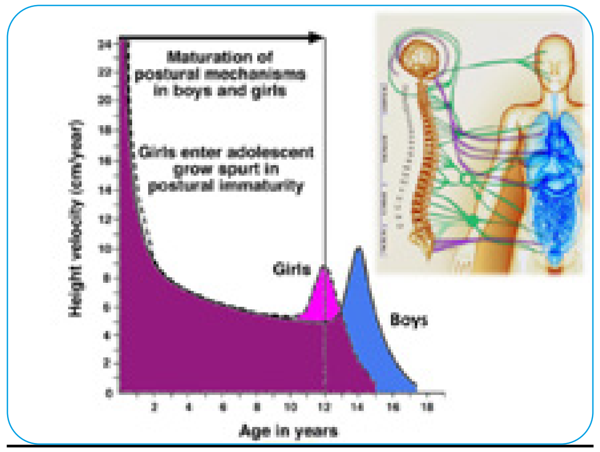
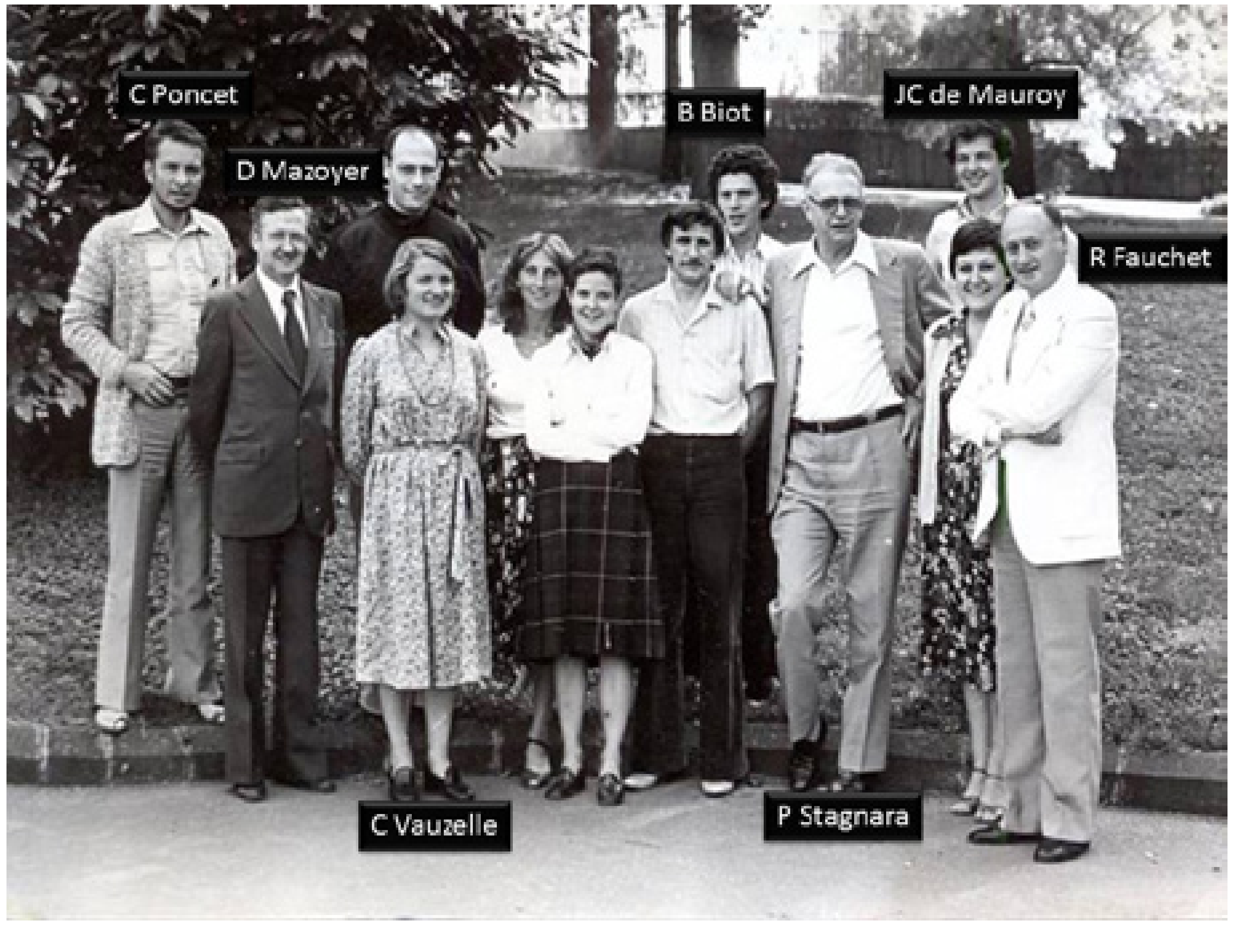



Fig 20.9 20% boys (NOTOM)




The Centre des Massues medical team in 1978. Pierre Stagnara surrounded by his assistants and residents.





*Chapter 21*

# 21. From tips to tricks

**"Being good isn't enough. You have to be great."**

**Simon Cowell**

## The 21 original concepts of the Lyon Method

The Lyon Method comprises a number of original concepts which form a coherent whole in the conservative treatment of scoliosis. We have compiled the 21 most important features.

### *Coupling exercises and brace*

From the earliest days of the Lyon Method, gymnastic exercises were combined with braces to correct deviation. At the beginning of the 20th century, plaster replaced most corrective appliances (Fig 21.1).

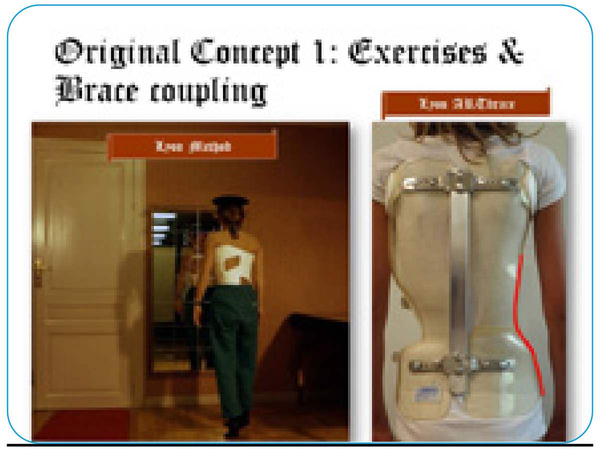



Fig 21.1 Exercise and brace coupling

### *Plastic deformation*

Today, plaster has been replaced by ARTbrace 24/24 full time, whose high strength enables superior correction than plaster. This maximum correction of the curve remains one of the best ways of achieving plastic deformation of the paravertebral ligaments and restoring tensegrity. Plastic deformation of the soft tissues also enables conservative treatment of scoliosis after Risser 2 and in adulthood (Fig. 21.2).

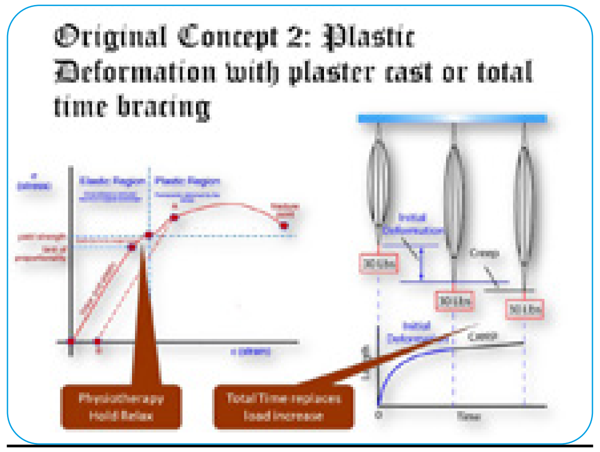



Fig 21.2 Plastic deformation

### *Isostatic equilibrium in the sagittal plane*

For many years, scoliosis was considered only on frontal radiographs. In the 1980s, the French school published the first morphotypology studies in the sagittal plane, emphasizing the fundamental role of lumbopelvic incidence on the other sagittal curves of the spine. Correlations with pelvic incidence lead to sagittal isostatic balance and the use of the sagittalometer. The vertical red line defines the sagittal isostatic balance as a function of pelvic incidence. This isostatic balance conditions physiotherapy and 3D correction using coupled movements (Fig 21.3).

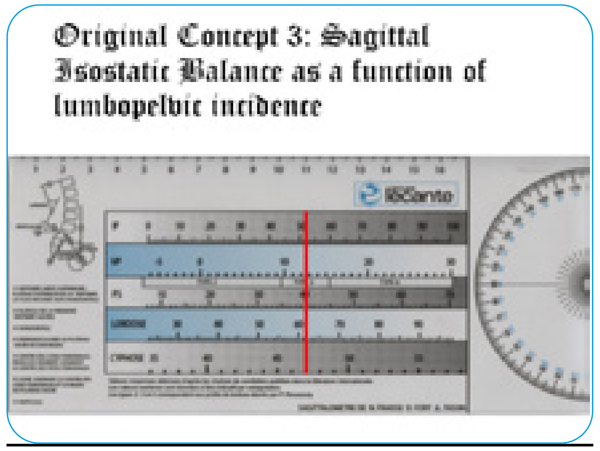



Fig 21.3 Using the Sagitallometer

## Stimulation of the postural system

Empirically, Lyon Method physiotherapy has always been based on the postural system, according to Jean Pierre Flourens's experiments on the scoliotic pigeon. Scientific work confirming a disturbance of the postural system dates back to Sahlstrand and Nachemson. Burwell then developed the Neuro-osseous timing of maturation (NOTOM), with postural mechanisms maturing at the age of 12 in both boys and girls, who thus begin their growth spurt before the postural system has fully matured. This would explain the lower frequency of scoliosis in boys, who begin their pubertal growth spurt after the postural system has matured (Fig. 21.4).

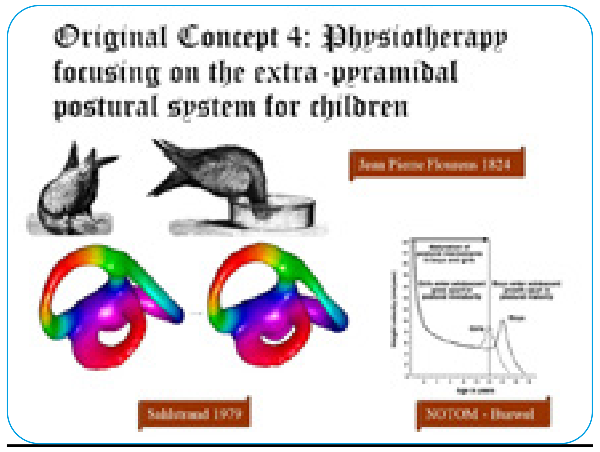



Fig 21.4 Balanced semicircular channels

## The 4 tracts of the extrapyramidal system

The reticulospinal tract manages static balance in the standing position. The vestibulospinal tract manages small imbalances around the cone of balance defined by Dubousset. The reticulospinal tract manages larger imbalances on the verge of falling. The tectospinal tract involves the eyes and the upper limb, explaining the use of the orthopedic mirror in scoliosis physiotherapy. The basic Lyon Method exercises stimulate the 4 pathways of the extrapyramidal system (Fig 21.5).

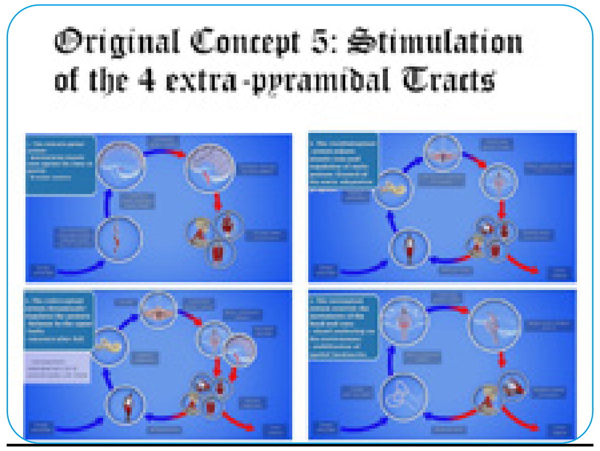



Fig 21.5 Stimulation of the 4 tracts

## Static and dynamic balance

At muscle and joint level, the sensors are duplicated; statesthetic and kinesthetic. Exercises should be varied to suit each sensor. In fact, both types of receptor at muscle and joint level will need to be stimulated during the physiotherapy session. In the absence of a treadmill, walking on the spot and skipping rope stimulate the dynamic sensors (Fig 21.6).





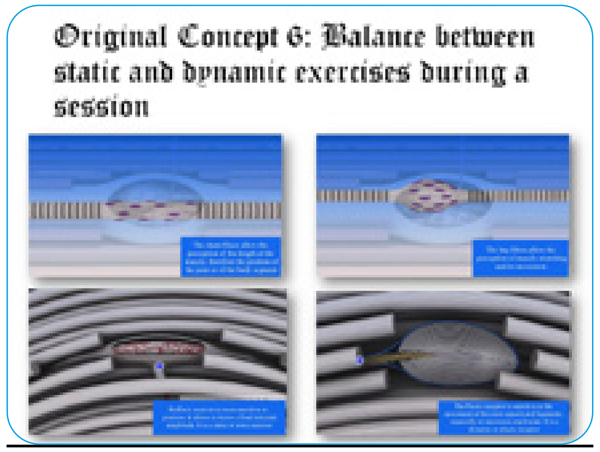



Fig 21.6 Static and dynamic stimulation

## Chaotic and linear scoliosis

Beyond 25°, the linear evolution of scoliosis has been well described for both neurological and idiopathic scoliosis. It is linked to a vicious circle described by Ian Stokes. With school screening, a large number of scolioses have been discovered at an angulation of less than 20°, and these scolioses evolve in only 10% of cases. To date, there is no predictive test for the evolution of these scolioses, and deterministic chaos best describes the dynamic behavior of scoliosis below 20° (Fig 21.7).

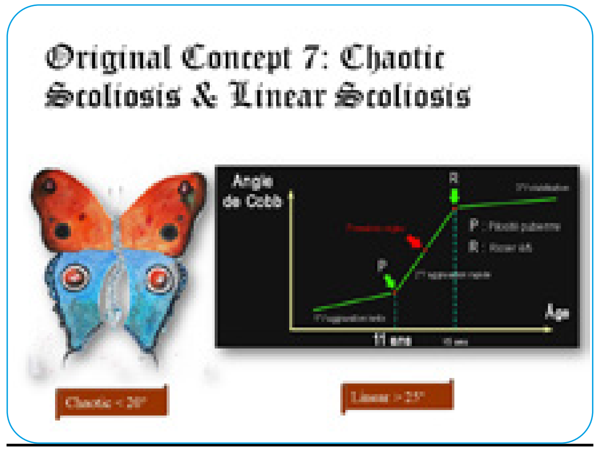



Fig 21.7 Chaotic and linear scoliosis7

## 3D using coupled movements

The 3D correction of scoliosis using coupled movements is based on the sagittal isostatic balance of the spine in the sagittal plane. This isostatic balance is that of maximum spinal mobility. It is in this position that frontal correction is most effective. Regional scans in the corrected position confirmed Punjabi's law of coupled movements (Fig 21.8).

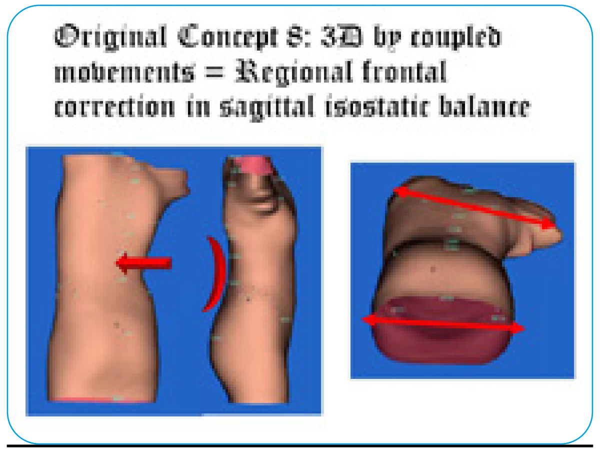



Fig 21.8 Detorsion by coupled movements

## Thoracic bending

At the thoracic level, the facet joints lie in a plane close to the frontal plane, allowing rotation around the sagittal axis. Flexion is therefore favoured at the thoracic level (Fig 21.9).

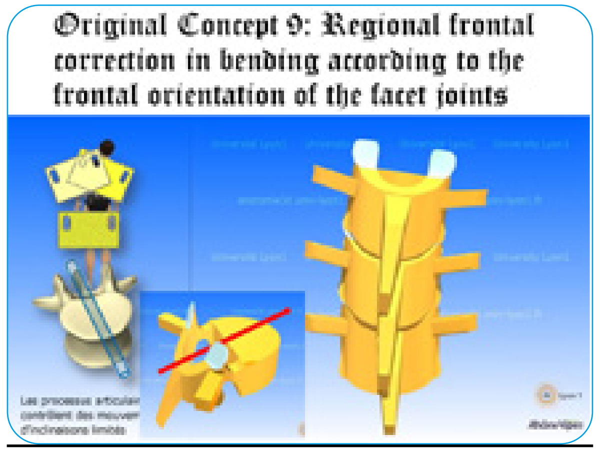



Fig 21.9 Thoracic bending

## Lumbar shift

At the lumbar level, on the other hand, the facet joints are in a sagittal plane, which favors mobility in the sagittal functional plane, but imposes translation in the frontal plane along the transverse axis of the vertebra. This is the "shift". This translation is favoured by the height of the intervertebral disc at the lumbar level (Fig 21.10).

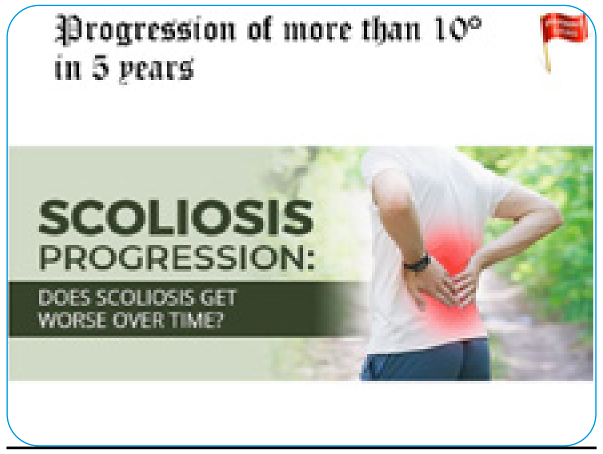



Fig 21.60 Progress monitoring

On the left, alignment is static; on the right, balance is dynamic. Frontal misalignment is generally towards convexity. Joint rigidity limits correction of the postural system. Malalignment must not exceed Dubousset's cone of economy (Fig 21.61).

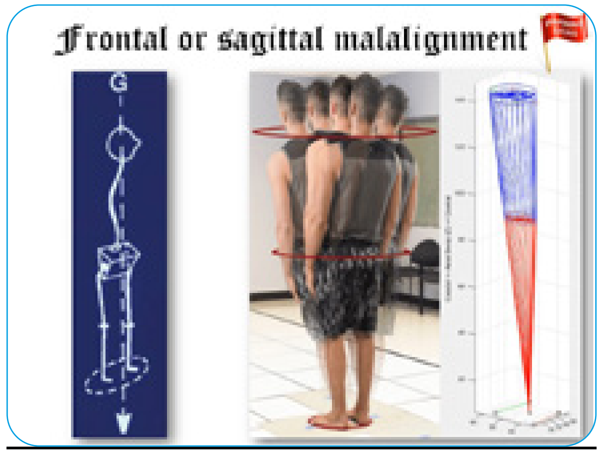



Fig 21.61 Spine-saving cone

The bi-crest line usually crosses L4. When it intersects L5, we speak of an exposed hinge. This morphotype favours mobility, but also instability (Fig 21.62).

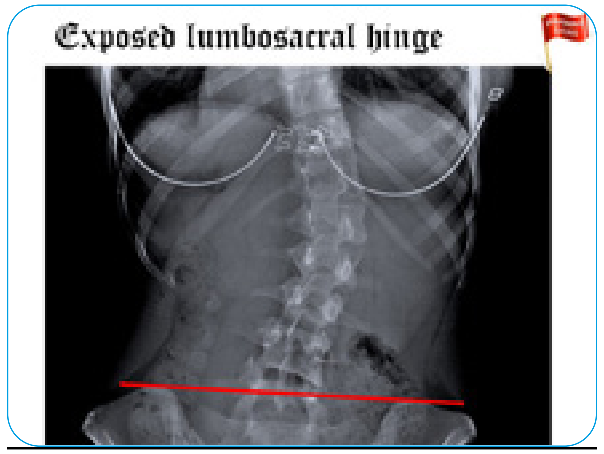



Fig 21.62 Bi-crest line

Rotational dislocation is the specific complication of adult scoliosis. It corresponds to a loss of alignment of the lumbar vertebrae. A translation of more than 6 mm is a warning sign (Fig 21.63).

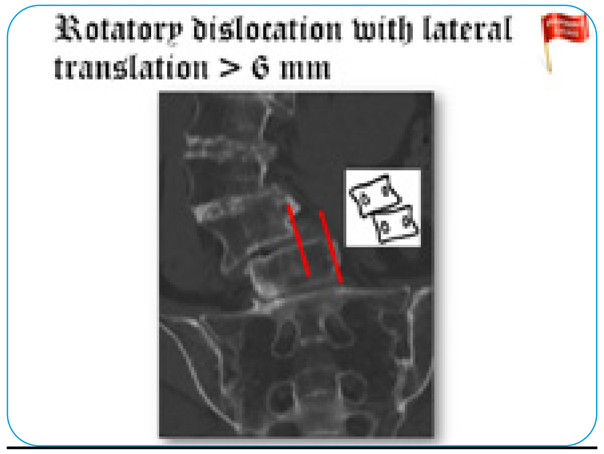



Fig 21.63 Rotational dislocation

### *In conclusion,*

*There's no real secret to the Lyon Method; the physiological and biomechanical basics are common knowledge. Even though 200 years of experience have enabled us to select the most useful elements, thanks to you, the method will continue to evolve. Be inventive and adapt your exercises to each patient. Be ready to change, to learn, but remain yourself. Set an example and pass on your knowledge to the younger generation in your country. That's what this certification is all about.*





## Epilogue

Over the course of this century, scoliosis has experienced many vicissitudes. From the opprobrium of orthopedics to the great congresses that bring together the highest intelligence in the field; from physiotherapy methods that fanaticize some and increase the skepticism of others; from empirical treatments to hundreds of braces, each more effective and three-dimensional than the last, everyone holds their own truth. What if everyone was right, and order arose from this apparent disorder?

### *What is scoliosis?*

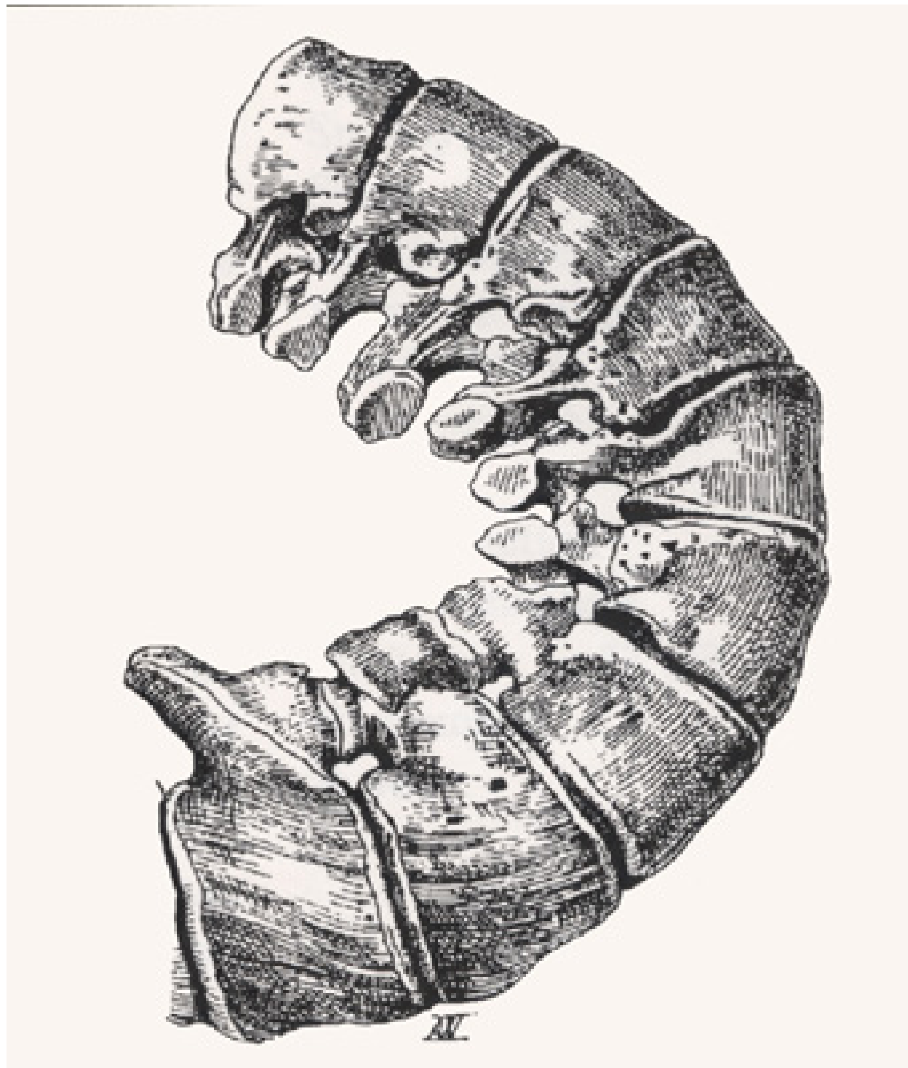
It's probably a deformation of the spinal column of a vertebrate that once adopted an upright posture. It is surely a programmed reaction of the organism to multiple factors that we know better and better, but none of which we can predict.
Like the snowflake, which is an intermediate state between water and ice and always divides into six branches, but no two are alike, scoliosis adopts certain anatomo-radiological forms, but all are different. Just as the flapping of a butterfly's wings in Brazil can cause a tornado in Texas, a small defect, for example in posture, can cause scoliosis. This is a kind of metastable state of the spine, which evolves from one stable straightness to another stable balance thanks to the flexibility of the spine. The problem is to predict whether we have reached this new state of stability by the time we see the patient. As it is illusory to chase the butterfly to avoid the tornado, global physiotherapy is the only way to help the body acquire its new state of stability as quickly as possible.

### *What is adolescent idiopathic scoliosis?*

During this evolution, which constitutes the natural history of scoliosis, pubertal growth is a period of maximum bone fragility. From the thresholds we have described, a "turbulence" will asymmetrically collapse the posterior wall of the apical vertebral body and sometimes of the adjacent body, as was well illustrated by Albert at the beginning of the century (Fig. 1).
This is followed by extension and inflection, clinically characterized by a flat back. Secondary rotation will deform the vertebral body and the orientation of the posterior joints, preventing any anatomical healing of the scoliosis.
The same turbulence can also affect the ribcage, where convex ribs can become angularly deformed, making the brace very difficult to apply.
Conservative orthopedic treatment, which unloads the vertebral body and aesthetically shapes the rib cage, is the most effective way to wait for sufficient bone maturity. Unfortunately, if at this stage the body has not reached its new state of stability, the evolution will continue, and surgery will be necessary to stabilize the scoliosis definitively.
The practice of conservative orthopaedics is a thankless one, requiring patience, perseverance and constant attention. What a gulf between the brilliant and rapid results of surgery and the vertebral stability that is difficult to acquire and maintain. But what a joy it is to preserve this child's spinal mobility. The plasticity of the skeleton is such that a young girl with a molded, supple thorax will emerge from the straightening machine.
When it comes to scoliosis, two opposing excesses must be avoided. Sometimes, the septic practitioner will advise disregarding any long and difficult therapy, or indoctrinated by the physiotherapy method or the miracle brace, he will entrust to ignorant hands the care of treating a child who will evolve towards a surgical stage.
In orthopaedics, results are difficult to assess. So many rapid and supposedly definitive successes which, after being examined by experience and time, have turned out to be failures. We have tried to objectively illustrate a conservative orthopedic treatment that is effective but elitist because it is difficult for the doctor, the child and his family. We believe that, at the dawn of the third

millennium, its principle remains valid and that every sociologist should propose it in its most effective form, when the alternative with surgery is still possible, thus respecting the patient's freedom of choice.

Apical vertebral deformity drawn by Albert and reproduced on all orthopedic treatises published in 1902 (Kirmiss on. Schulth ess. Hoffa. Villemin , Lüning).



*«25 years ago, I finished writing the world's first book on the non-surgical treatment of scoliosis. For this 2nd edition, I can measure the progress and results of the Lyon Method in France, Italy and around the world, thanks to on-line certification».*

*Jean Claude de Mauroy*

## Certification to the Lyon Method

Since 2020, International Online Certification has been open to all healthcare professionals, mainly physiotherapists, orthoprosthetists and doctors who wish to specialize in the field of scoliosis and possibly teach a validated, proven method. It is for them that I have written this book, and it is for them that I have had the courage to improve the photos in the first edition from gray to color.

## Scoliosis & Spine Online Learning

SSOL and its co-founder Andrea Lebel offer not only the technical support required for certification, but also expertise in global educational needs. All documents can be translated and supplied in their original version for teaching in 26 mother tongues. Over the years we've worked together, I've come to appreciate his skills and availability. I'm delighted by her interest in the Lyon Method.

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*Non-surgical treatment of Scoliosis and other vertebral deviations: Lyon method*

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