"Brace Technology" Thematic Series –

The Lyon brace in the treatment of scoliosis

Jean Claude de Mauroy\textsuperscript{1\$}, Cyril Lecante\textsuperscript{2*}, Frédéric Barral\textsuperscript{2*}

\textsuperscript{1}Clinique du Parc, 155 boulevard Stalingrad 69006 Lyon, France
\textsuperscript{2} Groupe Lecante, 125 rue Bataille 69007 Lyon, France

*These authors contributed equally to this work

\textsuperscript{\$}Corresponding author

Email addresses:

JCDM: demauroy@aol.com
CL: lecante@lecante.com
FB: frederic.barral@lecante.com
Abstract

The Lyon Brace or adjustable multi shells brace has been used for more than 60 years. The management of the Lyon Brace includes:

- the realization of one or two reductive plaster casts, which enable a true lengthening of the concave ligaments;
- an oriented or electronic moulding after the removal of the plaster cast,
- a blueprint adapted to Lenke’s classification,
- a specific physiotherapy.

Background

The Lyon Brace was created in 1947 by Pierre Stagnara. The brace is:

- Adjustable on seven centimetres of growth, and seven kilograms of weight.
- Active: Because of rigidity of the PMM (polymetacrylate of methyl) structure, the child is stimulated. The active axial auto correction decreases the pressures.
- Decompressive: The effect of extension between the two pelvic and scapular girdles decreases the pressure on the intervertebral disc and allows a better effectiveness of the pushes in the other planes.
- Symmetrical: In addition to the aesthetic aspect, the brace is much easier to build.
- Stable: The stability of both shoulder and pelvic girdles facilitates the intermediate 3D corrections.
- Transparent: Usually, it is not necessary to use “pads”; so we can control directly the pressure of the shells on the skin.
Brace description
On two vertical bars are fixed from bottom to top:

- two pelvic shells insuring the optimal stability of the brace,
- one lumbar shell T12-L4 either independent, or extending at the abdominal chondrocostal level,
- one thoracic shell at the level of the scoliotic convexity,
- one opposite thoracic shell used as a counter push,
- one shoulder balance shell on the side of the thoracic convexity.

Long term follow up results.
We have only retrospective studies, but we bring forward the results of 1228 complete treatments checked minimum two years after the weaning of the brace.

11% of the curves get worse by more than 5° according to the initial curves, that is to say, an effectiveness index of 0.89.

We isolated a group of 117 scoliosis which treatment started at Risser 0. The global progressive angular mean curve can be superimposed on the statistic general curve.

The effectiveness index is 0.74.

Failure rate is 2% concerning scoliosis with an initial curve below 45°.

Conclusion
The Lyon Brace is the historical reference of bracing AIS. To be fully effective, it requires a plaster cast at least one month and a specific physiotherapy. For the moment, the results are only retrospective, and it is necessary to carry out prospective studies.

Introduction
The Lyon Bracing Management evolved since 1947 as cooperation between Pierre Stagnara MD (Figure 1) and Bouillat & Terrier CPO. [1] The Lyon management requires of a reduction with a plaster cast from one to four months, before moulding the brace. It is a under arm adjustable brace without any superstructure. [2] Very early braces were made from a combination of steel and leather. (Figure 2)

After the Second World War, Régis Lecante CPO notice that the cockpit of a Messerschmitt fallen close to his country house is out of very resistant plastic. The plastic allows tapping and direct screwing. The use of the PMM (polymetacrylate of methyl) or plexidur™ was born and will replace leather. (Figure 3, 4)
History of the Lyon brace

The Lyon Brace, created in 1947 by Pierre Stagnara is:

- Adjustable on seven centimetres of growth, it’s efficient. We do not need to change the brace every six months.

- Active: Because of rigidity of the PMM structure, the child is stimulated. The active axial auto correction decreases the pressures.

- Decompressive: It is the consequence of the “Adjustable”. The effect of extension between the two pelvic and scapular girdles decreases the pressure on the intervertebral disc and allows a better effectiveness of the pushes.

- Symmetrical: In addition to the aesthetic aspect, the brace is much easier to build.

- Stable: The stability of both shoulder and pelvic girdles facilitates the intermediate corrections.

- Transparent: Usually, it is not necessary to use complementary pads. We can thus control directly on the skin the pushes, stops, drives and reliefs.
It is always realized after a reductive plastered cast in a Cotrel EDF frame. (Figure 5) The reduction by plaster cast has never been abandoned in Lyon, because we did not find a better solution. [3]

The physiotherapy begins with the plaster cast and is followed during bracing; it is an important part of the treatment.

**Theoretical principles**
Ligaments can retain their changed shape when stretched past a certain point or for a prolonged period of time. The plaster cast leads to increase of the length of the musculo-ligamentar structure of the concavity thanks to a continuous traction during four weeks minimum. The brace maintain the viscoelastic level of the structure, especially at night.

When the curve is above 30°, it carries out an anti-collapsing device during the day.

The axial elongation between scapular girdle and pelvic girdle is a characteristic of the Lyon Brace.

This elongation diminishes the constraints on the disc and makes easier the 3D correction of the scoliosis.

In the frontal plane, the action is made of 3 points system.
The thoracic derotation is obtained with a push on the internal side of the rib hump and an anterior chondrocostal concave counter push. We avoid every postero-anterior push on the rib hump to not increase the flat back. (Figure 6)

At the lumbar level, we realize the push on a convex transverse.

In the sagittal plane, we accentuate the lumbar lordosis in order to increase the kyphosis of the thoracic region by sagittal bending of the bars. (Figure 7) The stiffness of PMM (polymetacrylate of methyl) makes it an active brace.

When he is wearing the brace; the child tends, in fact, to elongate himself to diminish the pressure.

**Methods**

**Description of the brace**
Different curves require different pushes placements according to curve severity and location. [3]
The bars are in radio transparent duralumin, (figure 8)

the faceplate and joint in steel, (figure 9)

the thermo malleable plastic is made of PMM. (Figure 10)

It is made from top to bottom with:
- a pelvic basis insuring the optimal stability of the brace, (figure 11)
- a lumbar shell T12-L4 either independent, or extending at the abdominal chondrocostal level, (figure 12)
- an abdominal shell which refers to the anterior shell of the brace that extends enough laterally especially on the concave side to drive in derotation the anterior counter rib hump and in height to contain the abdomen and just barely cover the margins of the
ribs and xyphoid process like an abdominal apron. This shell is a key point for kyphotisation and derotation.

- A thoracic shell at the level of the scoliotic convexity, (figure 13)

- an opposite thoracic shell used as a counter push, (figure 14)

We can eventually use a little axillary shell to balance the shoulders on the side of the scoliotic convexity. The shells are fixed on the two bars by metallic plates allowing some modifications with growth. (Figure 15)

The PMM shells realize according to the application: a stop, a drive or a push.

We use three kinds of brace:

**The Lyon classical thoracic or double major brace.**

It is composed of:

- a pelvic girdle with two hemi shells and two posterior and anterior bars which allow the adjustments,

- a medial thoracic push (T7-T12), a high thoracic push (T4-T7), a lumbar shell (T12-L4), an anterior chondrocostal asymmetric shell and eventually an axillary balancing scapular support. (Figure 16)
The Lyon lumbar brace.
It was created by Michel and Allègre. [4]

There are three main components:
- an ilio-lumbar shell (T11-L4) on the convex side with a characteristic horizontal support on the iliac crest what provoke a reflex of axial extension.
- A trochanteric hemi circle on the concave side
- A thoracic shell (T6-T12) on the concave side.

(Figure 17)

The Lyon thoraco-lumbar brace.
It is a 3 points high brace with:
- A Large thoraco-lumbar push (T6-L2), there is no lumbar shell,
- A high thoracic push (T4-T7). The lever arm is maximal in the coronal plane.

(Figure 18)

Indications
The minimal curves' indications are the one defined by the SRS, that is to say, 20° and more during the fast puberty growth (11 to 13 years old for girls) and 30° during descending puberty growth. We do not realize any preventive treatment. In some cases, the treatment is anticipated when there are some familial inheritances, a big rotation or an unbalance of the occipital axis. Sometimes we treat scoliosis of more than 40° when surgery indication is refused by the parents.
The Lyon brace is perfectly suitable for puberty growth. Before, we prefer to use the Milwaukee brace, which is better because it does not deform the thoracic cage. It is used whatever the aetiology is as long as the child walks.

For neurological scoliosis in a wheelchair, we use the soft Lyon Brace in high or low polyethylene density. (Figure 19)

**Prescription of the Lyon Brace**
To every 14 types of Lenke’s classification matches a blue print. [3,5]

We summed them up for right thoracic and left lumbar curves. (Figure 20)

<table>
<thead>
<tr>
<th></th>
<th>Lyon thoraco-lumbar</th>
<th>Right Thoraco-lumbar Push T5-L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>3 points high</td>
<td>Left Thoracic Push T4-T7</td>
</tr>
<tr>
<td></td>
<td>Without axillary balance support</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Lyon thoracic</th>
<th>Right Thoraco-lumbar Push T5-L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>With lumbar stop</td>
<td>Left Lumbar stop L1-L4</td>
</tr>
<tr>
<td></td>
<td>Without axillary balance support</td>
<td>Left Thoracic Push T4-T8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Lyon thoracic</th>
<th>Right Thoraco-lumbar Push T5-L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1C</td>
<td>With lumbar drive</td>
<td>Left Lumbar Drive L1-L4</td>
</tr>
<tr>
<td></td>
<td>Without axillary balance support</td>
<td>Left Thoracic Push T4-T8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Lyon thoraco-lumbar</th>
<th>Right Thoraco-lumbar Push T8-L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>3 points high</td>
<td>Left Thoracic Push T5-T7</td>
</tr>
<tr>
<td></td>
<td>Right axillary balance support</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Right Thoracic Push T8-L1</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>2B</td>
<td>Lyon thoracic With lumbar stop</td>
<td>Right Thoracic Push T8-L1</td>
</tr>
<tr>
<td>2C</td>
<td>Lyon thoracic With lumbar drive</td>
<td>Right Thoracic Push T8-L1</td>
</tr>
<tr>
<td>3A</td>
<td>Lyon thoracic With lumbar stop</td>
<td>Right Thoracic Push T5-T12</td>
</tr>
<tr>
<td>3B</td>
<td>Lyon thoracic With lumbar drive</td>
<td>Right Thoracic Push T5-T12</td>
</tr>
<tr>
<td>3C</td>
<td>Lyon thoracic With lumbar push</td>
<td>Right Thoracic Push T5-T12</td>
</tr>
<tr>
<td>4A</td>
<td>Lyon thoracic With lumbar stop</td>
<td>Right Thoracic Push T8-T12</td>
</tr>
<tr>
<td>4B</td>
<td>Lyon thoracic With lumbar drive</td>
<td>Right Thoracic Push T8-T12</td>
</tr>
<tr>
<td>4C</td>
<td>Lyon thoracic With lumbar push</td>
<td>Right Thoracic Push T6-T12</td>
</tr>
</tbody>
</table>
The protocol
The plastered cast and the adaptation of the Lyon brace are realized in Day Hospital.

The protocol depends on the angle of the scoliosis and is summed up in (Table I).

<table>
<thead>
<tr>
<th>Angulation scoliosis</th>
<th>Nb and time of the plaster cast</th>
<th>Wearing of the Lyon brace</th>
<th>Weaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30°</td>
<td>1 cast - 1 month</td>
<td>nightly</td>
<td>End of height growth</td>
</tr>
<tr>
<td>30-40°</td>
<td>2 casts – 1 month each</td>
<td>After school 16h/24</td>
<td>1 year after the end of height growth</td>
</tr>
<tr>
<td>&gt; 40°</td>
<td>2 casts – 2 months each</td>
<td>23h/24</td>
<td>2 years after the end of height growth</td>
</tr>
</tbody>
</table>

Tableau I – Protocol of the Lyon Brace

The physiotherapy is practiced twice a week during the plaster cast and then once a week during the wearing of the brace. We allow the removal of the brace without any limit to practice sports.

Physiotherapy
The principles are the following ones:

- No complex material. All the exercises have to be repeated at home.
- No sportive counter indication. The sport practiced by the child must be continued:
- By adapting if necessary the sportive gesture (avoiding deep quick inspiration, and forward flexion of the trunk)
- By completing if necessary, the sportive activity with a specific physiotherapy.
- The exercises are symmetric in the frontal plane.
- No chapel and miracle exercise. Choosing the best technical way for every child, at every age, and every therapeutic sequence.
- No revolution, therefore but an evolution in the exercises which are repeated few minutes a day at home. [7,8]

We treat a child and not a scoliosis or an X-ray. The look of the child is fundamental. Sometimes asymmetric with plagiocephaly, it evokes a juvenile scoliosis, but most of all it expresses a mood: worry, scare, anxiety, despair, indifference, disappointment, aggressiveness. It is our role to change this look to reliance and complicity. (for more details see Additional file 1)

**Results**

We show the results of 1338 scoliosis treated in France and in Italy according to the above indications. All the assessments have been done by the same physician (JCdM). The data are automatically written on the Excel table by the secretary during the check up two years after the removal of the brace. According to the SRS norms, we have included the scoliosis treated previously with the Milwaukee brace. The failures with evolution towards surgery are included. Every scoliosis not checked at least two years after the weaning of the brace are excluded. Considering our recruitment, most of the scoliosis is idiopathic. We have excluded the patients in Soft Lyon brace.
The evaluation criteria are classical. The mean case is a 13 year and 10 months old girl (+1.7) at the beginning of the treatment. Her height when she is standing up is 159.81 cm (+11), her weight is 47.04 Kg (+9), her vital capacity of 2.20 l (+7).

Two years after the weaning of the Lyon brace, her height is 165.00 (+6.7), her weight is 54.85 (+8.17), her vital capacity is 2.63 (+6.2).

We grouped all the scoliosis according to the type of Lyon Brace realized. The results are expressed in Cobb’s angle and in percentage of reduction according to the initial angulation in (Table II).
We have, as well, put together the esthetical results at the rib hump level (Rib H) measured in mm. (Table III)

<table>
<thead>
<tr>
<th></th>
<th>Rib H initial</th>
<th>Rib H Corset</th>
<th>Rib H weaning</th>
<th>2 years after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyon Thoracic (thoracic) 285 cases</td>
<td>25.43 (+8.68)</td>
<td>10.12 (+7.52)</td>
<td>15.54 (+8.39)</td>
<td>17.03 (+8.70) 33 %</td>
</tr>
<tr>
<td>Lyon Thoracic (double major) 351 cases</td>
<td>19.32 (+9.61)</td>
<td>7.55 (+5.86)</td>
<td>11.96 (+7.13)</td>
<td>13.21 (+7.71) 32 % / 50 %</td>
</tr>
<tr>
<td>Lyon Thoraco-Lumbar 279 cases</td>
<td>21.72 (+7.31)</td>
<td>6.20 (+5.35)</td>
<td>11.23 (+5.73)</td>
<td>11.62 (+6.74) 46 %</td>
</tr>
<tr>
<td>Lyon Lumbar 450 cases</td>
<td>17.42 (+7.37)</td>
<td>2.55 (+2.70)</td>
<td>5.59 (+4.42)</td>
<td>6.33 (+5.43) 64 %</td>
</tr>
</tbody>
</table>

Table III – Results in mm about Rib Hump

In accordance to international norms, we evaluate the results two years after the weaning of the brace divided between:

- Good, i.e. a gain of more than 5° according to the initial curve
- Stable, i.e. + 5° according to the initial curve
- Failure, i.e. a loss of more than 5° according to the initial curve

For double major scoliosis, we compared half the sum of the two curves.
We present the results in (table IV).

<table>
<thead>
<tr>
<th></th>
<th>Gain &gt;5°</th>
<th>Gain ± 5°</th>
<th>Loss &gt; 5°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyon Thoracic (thoracic) 285 cases</td>
<td>140</td>
<td>85</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>54.26 %</td>
<td>32.95 %</td>
<td>12.79 %</td>
</tr>
<tr>
<td>Lyon Thoracic (double major) 351 cases</td>
<td>208</td>
<td>127</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>59.26 %</td>
<td>36.18 %</td>
<td>4.57 %</td>
</tr>
<tr>
<td>Lyon Thoraco-Lumbar 279 cases</td>
<td>189</td>
<td>76</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>67.74 %</td>
<td>27.24 %</td>
<td>5.02 %</td>
</tr>
<tr>
<td>Lyon Lumbar 450 cases</td>
<td>362</td>
<td>84</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>80.44 %</td>
<td>18.66 %</td>
<td>0.88 %</td>
</tr>
<tr>
<td>Total 1338 cases</td>
<td>899</td>
<td>372</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>67.19 %</td>
<td>27.80 %</td>
<td>5.00 %</td>
</tr>
</tbody>
</table>

Table IV – Results at ± 5°

We isolated a group of 174 scoliosis which treatments were initialized at Risser 0. We can, thus, compare the results obtained comparing the average of the main and secondary curves. (Table V)

<table>
<thead>
<tr>
<th></th>
<th>Cobb initial</th>
<th>Cobb plastered</th>
<th>Cobb Brace</th>
<th>Cobb weaning</th>
<th>2 years after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cases 1338 cases</td>
<td>28.51 (+-7.14)</td>
<td>8.09 (+-7.16)</td>
<td>10.75 (+-7.69)</td>
<td>21.27 (+-9.09)</td>
<td>21.80 (+9.48) 24 %</td>
</tr>
<tr>
<td>Group Risser 0 174 cases</td>
<td>27.23 (+-6.46)</td>
<td>5.24 (+-6.65)</td>
<td>8.85 (+-6.88)</td>
<td>21.85 (+-8.98)</td>
<td>22.31 (+-10.22) 18 %</td>
</tr>
</tbody>
</table>

Table V – Angular results in Cobb’s degree and percentage of reduction compared to the initial angulation.

If the treatment is begun with an angulation lower than 40°: only 2 % requires surgery. For more than 40°, the percentage is 20%.

We can study, as well, the 2 groups according to a gain above 5°, stability at ± 5° and a loss of more than 5°. (Table VI)

<table>
<thead>
<tr>
<th></th>
<th>Gain &gt;5°</th>
<th>Gain ± 5°</th>
<th>Loss &gt; 5°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cases 1338 cases</td>
<td>899</td>
<td>372</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>67.19 %</td>
<td>27.80 %</td>
<td>5.00 %</td>
</tr>
<tr>
<td>Group Risser 0 174 cases</td>
<td>85</td>
<td>54</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>48.89 %</td>
<td>31.11 %</td>
<td>20 %</td>
</tr>
</tbody>
</table>

Table VI – Results at ± 5°
Discussion
The results of the Lyon Management were confirmed by numerous teams in Europe.
[9,10] Because of the necessary recovery for the plaster cast, many teams looked for other solutions without preliminary plaster cast reduction. [11] The results are debatable [12]
The Lyon braces have followed the progress of technology while conserving the fundamental biomechanics principles.
For 20 years, the Lyon Brace is realized and evaluated in the same way in some public and private structures either in France or in Italy. The results are coherent and the variations in time are linked to the screening and a lower initial angulation.
The initial reduction by a plaster cast enables a moulding on a corrected spine. The X-Ray with the plaster cast is used as a reference to adapt the brace. This reduction enables a night bracing, which is very appreciated by the child, when the curve is below 30°.
Lenke’s classification seemed to us well adapted to the prescription of a Lyon brace.
So the physician has only to classify the curve and the CPO know how to realize the most adapted brace.
The best indication for the Lyon Brace is the puberty growth, when the constraints on the rib cage do not risk leading to a tubular thorax. The statistics do not correspond to all the scoliosis we treat, but to some patients whom we select because we think the Lyon Brace will be more effective.
When a treatment has been done before, the initial angulation is the one before the plaster cast.
The realization of a plaster cast at the beginning of the treatment may select the most motivated patients, for who compliance is the best. In the same way, we have many drop-outs at the end of the treatment and only the motivated ones come to the check-up.

When a patient is operated, he is included in the statistics, and we repeat the angulation before surgical intervention.

The important Standard Deviation of the Cobb’s angle of our series shows the important amplitude of indication, from the weaker curve to the most important; the only variable is going to be the time of wearing the brace during the day.

The best results are obtained for lumbar scoliosis. The brace is short, well tolerated and those curves are often painful at adult time. Those are the ones which evolve towards rotatory dislocation.

The double major curves react well to the Lyon Brace, despite the short lever arm in the frontal plane.

The thoraco lumbar curves react well, in the same way, to the Lyon Brace type 3 points high. The excellent lever arm enables a good correction thanks to the plaster cast; nevertheless, it is in this group that we find again most of the scoliosis which evolve towards surgery even if we follow the treatment acutely. We insist on the strict wearing of the brace, despite the impressive corrections which we can sometimes note when the patient wears a plastered cast.

The rib hump is better corrected than the angulation which is reduced of 1/3 at the thoracic level and more than 50% at the lumbar level. The esthetical aspect is always better than the X ray.
The excellent global index of effectiveness of all the curves is 0.95, and it can be explained by the selection of the patients. The index is only 0.87 for the thoracic curves. The most characteristic group to judge the effectiveness of the Lyon Brace is the Risser 0 group. In this group the index of effectiveness of the most progressive scoliosis is 0.80.

But if we compare the mean curves of the Risser 0 group with the mean curves of the general statistics, the two curves are almost the same, as if the Lyon Brace was stopping the scoliotic curves whatever the age of the child.

Even if the index of effectiveness seems to be better, it is very hard to compare the results of the Lyon Brace with the one of the other braces published in the literature.

The main indication at puberty growth may explain the good results.

The specific physiotherapy is a basic part of Lyon Management. The interest of the physiotherapy associated with the brace was proved by Négini. [13]

**Contra indications to bracing**
- Juvenile and infantile scoliosis to avoid a tubular thorax.

- Sever thoracic lordosis which treatment is usually surgical. We can wait for surgery with a Lyon brace focalized on the lumbar curve to limit the more we can make the fusion of the low lumbar vertebras.

- Major psychological reactions. The conservative treatment from Lyon is the most elitist, but when the child and the family accept the plastered brace. The compliance is maximal.

**Conclusions**
The Lyon Brace management is a conservative orthopaedic treatment very effective and this fact is proven by the long term results that we present in this study. The day
hospital facility of the plaster cast and the Lyon Brace is cheaper than a classic hospitalization and enables the child to keep on going to school.

The easiness of the prescription of the brace coming from Lenke’s classification is reachable for everyone.

The easiness of adaptation of the brace during puberty growth enables a precise and optimal adjustment.

It is a complement to other braces and must be included in the therapeutic range of the scoliosis specialist.

This treatment provides the maximum chances to the child, and it provides the maximum chances of success to the physician.

**Competing interests**
The authors declare that they have no competing interests. The use of Lyon Brace is totally free without patent fees. The metallic kits are available at numerous suppliers.

**Authors' contributions**
J CdM design of the study carried out the medical literature research and drafted the manuscript, CL carried out the technical literature research. For more than 20 years, he leads the technical development of the Lyon brace. FB participated in drafting and revising the manuscript. All authors read and approved the final manuscript.

**Acknowledgements**
The authors are grateful to Lecante Group, Lyon for their kind support.

The authors wish to thank Sophie Pourret for her help in collecting the pictures.
References


6. de Mauroy JC. La scoliose : traitement orthopédique conservateur. Montpellier,Sauramps édit; 1996


**Figures**

**Figure 1** – Pierre Stagnara
Original picture taken in 1985 by JCdM

**Figure 2** – Original historic Lyon brace
Old Lyon Brace realized by Bouillat and Terrier

**Figure 3** – Lyon brace – posterior view
**Figure 4** – Lyon brace – anterior view

**Figure 5** – Cotrel’s EDF frame to realize the plaster cast

**Figure 6** – Biomechanical effect of the brace in horizontal plane

**Figure 7** – Lordotization of the posterior bar in sagittal plane

**Figure 8** – Vertical posterior bar

**Figure 9** - Faceplate in high steel

**Figure 10** - Thermo malleable shells made in PMM

**Figure 11** – Pelvic basis
Figure 12 – Lumbar shell
Figure 13 – Thoracic main shell
Figure 14 – Axillary counter push & opposite balance shell
Figure 15 – Metallic plates
Figure 16 – Lyon thoracic & double major brace
Figure 17 – Lyon lumbar brace
or Three points brace of Michel & Allegre
Figure 18 – Lyon thoraco-lumbar brace
Figure 19 – Lyon soft polyethylene brace
Figure 20 - Bueprints

corresponding to 14 types of the Lenke’s classification for a right thoracic and left lumbar scoliosis

Tables

Table I – Protocol of the Lyon Brace
The protocol depends on the angle of the scoliosis

Table II – Angular results in Cobb’s degree and percentage of reduction compared to the initial angulation
We grouped all the scoliosis according to the type of Lyon Brace realized. The results are expressed in Cobb’s angle and in percentage of reduction according to the initial angulation

Table III – Results in mm about Rib Hump
In this time, in France we did not use the Bunnel’s ATR.

Table IV – Results at +/- 5°
- Good, i.e. a gain of more than 5° according to the initial curve
- Stable, i.e. +/- 5° according to the initial curve
- Failure, i.e. a loss of more than 5° according to the initial curve
For double major scoliosis, we compared half the sum of the two curves.

**Table V – Angular results in Cobb’s degree and percentage of reduction compared to the initial angulation.**

Group of 174 juvenile scoliosis which treatments were initialized at Risser 0.

Comparison with the global statistics

**Table VI – Results at +/- 5°**

Study of the 2 groups according to a gain above 5°, stability at +/- 5° and a loss of more than 5°.

**Additional files**

**Additional file 1 – Physiotherapy during bracing**

The Lyon Method for physiotherapy was first published in 1978 [7]