Stud Health Technol Inform. 2010;158:157-166.
http://booksonline.iospress.nl/Content/View.aspx?piid=17010

European braces widely used for conservative scoliosis treatment

Theodoros B. GRIVAS[a,1], Angelos KASPIRIS[b]

[a1]*Department of Orthopaedics and Traumatology, Scoliosis Clinic, "Tzanio" General Hospital of Piraeus,– NHS, Tzani & Afendouli str, 18536, Piraeus, Greece*
[b]*Department of Orthopaedics and Traumatology, "Thriasio" General Hospital – NHS, G. Gennimata Av. 19600, Magoula, Attica, Greece*

Abstract. *Introduction.* A systematic examination of the braces commonly used lacks in literature.
Objectives. Description of the European braces widely used.
Methods. The history, design rationale, indications, biomechanics, outcomes and comparison between some braces are reported
Results. Cheneau Brace is used in France and other European Countries. There are two Cheneau derivatives, namely the Rigo System Cheneau Brace used in Spain and the ScoliOlogiC® "Chêneau light" used in Germany. The Lyonnaise Brace is used in France and Italy. The Dynamic Derotating Brace DDB is used in Greece. The TriaC brace is applied in the Netherlands. The Sforzesco brace based on the SPoRT concept and the Progressive Action Short Brace PASB are used in Italy.
Conclusion - Significance. Correction of spinal deformities is achieved in conservative treatment with passive and active brace mechanisms. The mode of operation of modern braces is in accordance with various principles of correction, namely active or passive extension with the aid of a neck ring and correction by lateral pads, lateral pressure according to 3 – point principle, compression, bending the trunk towards the opposite side, active bracing and correction by means of pressure exerted by bands during movement and by means of metallic blades.
Recently there has been an effort to expand our insight on the biomechanics, the treatment management principles and the outcome description of the above mentioned braces. The peer review publications on these studies mandate the use of the SOSORT and SRS inclusion and assessment criteria for conservative scoliosis treatment.

Keywords. European scoliosis braces, Cheneau Brace, Rigo System Cheneau Brace, ScoliOlogiC® "Chêneau light", Lyonnaise Brace, Dynamic Derotating Brace DDB, TriaC brace, Sforzesco brace, Progressive Action Short Brace PASB

Introduction

Several published articles suggest that an untreated progressive idiopathic scoliosis (IS) curve may present a poor prognosis into adulthood including back pain, pulmonary compromise, cor pulmonale, psychosocial effects, and even death [1,2,3,4,5,6]. Bracing, even though it hasn't gained complete acceptance, has been the basis of non-operative treatment for IS for nearly 60 years, [7].

The majority of publications in the peer review literature refer to braces used in North America, [8], and there is a lack of systematic examination of the braces commonly used in Europe. The aim of this report, based on peer review publications on the issue, is to concisely describe the European braces which are widely used, focusing on their history, design rationale, indications, biomechanics, outcomes and comparison between them. Cheneau Brace, the two Cheneau derivative braces, namely the Rigo System Cheneau and the ScoliOlogiC® "Chêneau light", the Lyonnaise Brace, the Dynamic Derotating Brace (DDB) the TriaC brace, the Sforzesco brace and the Progressive Action Short Brace PASB will be described.

1. Cheneau Brace

Dr Jacques Chêneau built the brace during the 60's. In 1972 the first patient's results were obtained and officially presented in 1979 at Bratislava. Initially the brace was named Cheneau-Toulouse-Munster Brace as well.

[1] Corresponding Author: Department of Orthopaedics and Traumatology, Scoliosis Clinic, "Tzanio" General Hospital of Piraeus,– NHS, Tzani & Afendouli str, 18536, Piraeus, Greece, grivastb@vodafone.net.gr

Now it is accepted and used worldwide. Useful information on the brace and its philosophy can be found in http://cheneau.info. It is a rigid brace providing three-dimensional correction, Figure 1. The mechanisms of Chêneau Brace correction are a) passive mechanisms, namely 1) convex to concave tissue transfer, achieved by multiple three-point system acting in 3D, with the aim of curve hypercorrection, 2) elongation and unloading by the "cherry stone" effect, 3) Derotation of the thorax, 4) bending and b) active mechanisms, namely 1) vertebral growth acting as a corrective factor, 2) asymmetrically guided respiratory movements of the rib-cage, 3) repositioning of the spatial arrangement of the trunk muscles to provide their physiological action and 4) anti-gravitational effect, [9,10]. This brace opens anteriorly. After some modifications made by Dr Jacques Chêneau, since 1996 the brace is divided in 54 zones and provides large free spaces opposite to pressure sites. The hump should be pressed on 1/3 of the surface of apex. The corresponding dodging site involves 4/5 of the surface of the concave side of curve. Each of the remaining two pressure parts of the three-point system presses on 1/5 of the surface of the concave side. They are the apexes of the neighboring curves. Dodging opposite the latter sites allows movements and straightening of the curve in an active way. It is not permitted to hinder any of the three dodging areas, that is, the middle 4/5 of concave side and the 1/3 over and under the apex. Regarding the outcomes of brace application, the Cheneau-Toulouse-Munster brace has been found to decrease the coronal shift forward, the coronal tilt, the axial rotation, and to increase the sagittal shift forward and the sagittal vertebral tilt (3-D correction), [11], obtaining an average primary correction 41% (thoracic, lumbar, double) (n = 52 patients) and a long term correction 14.2% thoracic, 9.2% lumbar double curves: 5.5% in thoracic & 5.6% in lumbar, [12]. In a recent report, at the end of treatment there was an improvement of Cobb angle correction of about 23% and after 5 years there was a stabilization of about 15 % (p value < 0.05). Therefore, it could be stated that conservative treatment with Cheneau brace not only stops progression, but it also reverses the scoliotic curve [13].

2. Cheneau Brace derivatives

2a. Rigo System Cheneau Brace

This brace was developed by Dr Manuel Rigo during the early 90s in Instituto Èlena Salvá in Barcelona, Spain. The German - Spanish collaboration for brace production and information on manufacturing can be obtained at: http://www.ortholutions.de/start_english.php. The RSCB, Figure 2, is based on the Chêneau Brace, and it is able to produce the required combined forces to correct scoliosis in 3D. The blueprint of the brace is based on the idiopathic scoliosis curve classification correlated with brace treatment introduced by Dr Rigo [14]. The classification includes radiological as well as clinical criteria. The radiological criteria are utilized to differentiate five basic types of curves including: (I) imbalanced thoracic (or three curves pattern), (II) true double (or four curve pattern), (III) balanced thoracic and false double (non 3 non 4), (IV) single lumbar and (V) single thoracolumbar. In addition to the radiological criteria, the Rigo Classification incorporates the curve pattern according to SRS terminology, the balance/imbalance at the transitional point, and L4-5 counter-tilting. The principles of correction of the five basic types of curves are also described by Dr. Rigo, [14]. Biomechanically the RSC brace offers regional derotation. The rib cage and spine are de-rotated. The brace derotates the thoracic section against the lumbar section, with a counter-rotation pad at the upper thoracic region [15]. The brace also produces physiological sagittal profile. Initial reports on outcomes using this brace indicated a 31.1% primary Cobb angle correction and 22.2% primary torsion angle correction. At a follow up of 16.8 months 54% of curves were stable, 27% improved and 19% progressed, [16]. In patients with long thoracic curves treated with a recently described RSC brace design (three-curve-scoliosis brace with pelvis open) there was 76.7 % in-brace Cobb angle correction and 55.9% in-brace axial rotation correction [17]. The latter pattern is easy to correct according to the principles and it can not be compared to "Chêneau light" cohort**,** which in addition contains double curve patterns which correct least [18].

2b. ScoliOlogiC® "Chêneau light"

The brace, Figure 3, was invented by Dr. Hans-Rudolf Weiss. The application for the patent was presented in April 2005 and the first braces were built in May 2005. Useful information on the brace can be obtained in http://www.koob-scolitech.com/scoliologic.php and [18]. Weiss et al, 2007, reported 51% correction of Cobb angle (Cobb angle in the whole group of patients was reduced by an average of 16,4 degrees), 62 % correction for lumbar & thoracolumbar curve pattern, 36 % correction for thoracic scoliosis and 50 % correction for double major curve pattern. The correction effect correlated negatively with age ($r = -0,24$; $p = 0,014$), negatively with the Risser stage (-0,29; $p = 0,0096$) and negatively with Cobb angle before treatment ($r = -0,43$; $p < 0,0001$) [18].
From the experience obtained through the Chêneau light® brace a new CAD/CAM brace has been designed and applied more than 100 times by Dr. Weiss in 2009 which is called the Gensingen brace®, described in the 3rd. edition "Best Practice" in conservative scoliosis care [19]. There are blueprints to build a RSC® or a Chêneau light® brace according to the conservative treatment of AIS classification by Dr M. Rigo and Dr. HR Weiss [15,20].

3. Lyonnaise Brace

The Lyon Brace was created by Pierre Stagnara in 1947. Allègre and Lecante modified it to its present form using aluminium bars and plexidur (a high rigidity material) in 1958.
It is an adjustable rigid brace, without any collar, Figure 4. The bars of the brace are made of radio see-through duralumin, the faceplate and joint of high steel and the thermo malleable plastic is made of polymetacrylate of methyl. The treatment using Lyonnaise Brace is based on two main principles of treatment. An initial plaster cast to stretch the deep ligaments before the application of Lyon brace and the subsequent application of the adjustable brace. The blueprint is designed according to Lenke's idiopathic scoliosis classification and there are 14 design types. The indications for this brace are scoliotics 11-15 years old. It is not applied earlier to prevent tubular deformation of the thorax. The reported results detail an effectivity index (results of 1338 scoliosis treated in France and in Italy based on SRS - SOSORT treatment criteria 2 years after the weaning of the brace) 0,97 for lumbar curve, 0,88 for thoraco-lumbar curve and 0,80 for thoracic curve. The Cobb angle correction is reported for thoracic (n=285 cases) correction 12%, double major (n=351 cases) 10% and 25% respectively, thoraco-lumbar (n=279 cases) 24%, lumbar (n= 450 cases) 36%. Results are also obtained on cosmesis (hump in mm). The rib hump is better corrected than the Cobb angle, which is reduced by 1/3 at the thoracic level and by more than 50% at the lumbar level. The esthetical aspect is always better than the radiographs. In 1338 treated scoliotics, 67.19 % improved, 27.80 % were stable and 5.00 % deteriorated, [21, 22].

4. Dynamic Derotating Brace (DDB)

This brace was developed by the late Dr D. Antoniou and Dr J Valavanis at Athens, Greece. The first official announcement of Dynamic Derotating Brace (DDB) took place at the 21st common meeting of SRS and BSS, 1986. It is made of polypropylene with a soft foam polyethylene lining, Figure 5. This brace opens posteriorly, [23]. This is a TLSO type brace with anti-rotatory blades which act as springs - anti-rotatory devices, maintaining constant correcting forces at the pressure areas of the brace and, at the same time, produce movements in opposite directions of the two side-halves of the brace. The de-rotating metal blades are attached to the rear side of the brace corresponding to the most protruding part of the thorax (hump) or the trunk of the patient. They become active when their free ends are located underneath the opposite side of the brace and the brace is tightened by its straps, [24]. The forces applied by the de-rotating blades are added to the side forces exerted by the brace, and changing of the backward angle of the blades can modify them. The published outcomes reports detail an overall initial Cobb angle correction of 49.54% and at 2 years follow up a correction of 44.10%, [24, 25]. It was also reported that the overall 35.70% of curves improved, 46,42% were stable and 7.83% worsened – increased, [26]. As far as the cosmesis is concerned (Angle Trunk Inclination – ATI – hump), DDB improves the cosmetic appearance of the back of IS children with all but right thoracic curves, [27]. Study on quality of life after conservative treatment of AIS using DDB with the Brace Questionnaire (BrQ), which is specific for conservative treatment, revealed an influence on school activity and social functioning, but not on general health perception, physical functioning, emotional functioning, vitality, bodily pain, self-esteem or aesthetics, [28,29,30].

5. TriaC brace

This brace was developed by Dr Albert Gerrit Veldhuizen in Nederland. The name TriaC derives from the three C's of Comfort, Control, and Cosmesis. The TriaC orthosis has a flexible coupling module connecting a thoracic and a lumbar part, Figure 6. The TriaC brace exerts a transverse force system, consisting of an anterior progression force counteracted by a posterior force and torque, acts on the vertebrae of a scoliotic spine. In the frontal plane the force system in the TriaC brace is in accordance with the force system of the conventional braces. However, in the sagittal plane the force system only acts in the thoracic region. As a result, there is no pelvic tilt, and it provides flexibility without affecting the correction forces during body motion, [31,32]. The introducers suggest that the inclusion criteria are: IS with a Cobb-angle between 20 and 40 degrees, in skeletally immature scoliotics, with Risser 0–1 status, pre-menarche, post-menarche\1 year, in primary thoracic apex between the 7th and 11th thoracic vertebra and primary lumbar apex between the 2nd and 5th lumbar vertebra, in flexible spinal column as evidenced by at least 40% correction on bending films [33]. Some other studies suggest that the Triac™-Brace represents an alternative exclusively for the correction of lumbar curves [34]. An initial 22% correction is reported for the primary curves within the brace and 35% for the secondary curves. The improvement remained after bracing and in a mean follow up of 1.6 years, as long as it was above a threshold of 20%. In 76% of the patients there was control or net correction of IS curves [33]. It is stated that the TriaC brace significantly alters the predicted natural history of AIS, [33].

6. Sforzesco brace

The Sforzesco brace was developed by Stefano Negrini together with the CPO Gianfranco Marchini in 2004, in Milan, Italy, based on the SPoRT concept (Symmetric, Patient- Oriented, Rigid, Three-Dimensional, Active). The Sforzesco brace combines characteristics of the Risser cast and the Lyon, Chêneau-Sibilla and Milwaukee braces, Figure 7. Its main action is to push scoliosis from the pelvis up, so to deflex, derotate and restore the sagittal plane (three-dimensional action). For more information please visit http://isico.it/approach/default.htm. Results have been published superior to the Lyon brace [35] and similar to the Risser cast with less side-effects [36], making of the Sforzesco brace, according to authors, an instrument for worst cases [36,37]. It is based on the efficacy and acceptability correction principles. 1. Efficacy: a) the active brace: the patient is allowed (encouraged) to move freely, b) mechanical efficacy, achieved through pushes, escapes, stops and drivers (the last being a newly developed concept with this brace) c) versatility and adaptability; d) teamwork: MDs, CPOs, PTs patient & family, e) compliance. 2. Acceptability: a) body design and minimal visibility, b) maximal freedom in the Activities of Daily Life, c) assumption of responsibility and d) a cognitive-behavioural approach. The authors reported results on various outcomes (Cobb degrees and aesthetics) [38,39,40,41,42].

7. Progressive Action Short Brace (PASB)

The Progressive Action Short Brace (PASB) is used since 1976, for the treatment of thoraco-lumbar and lumbar idiopathic curves. It is a custom-made thoraco-lumbar-sacral orthosis (TLSO) brace of original design, devised by Dr. Lorenzo Aulisa, in Italy, Figure 8. The PASB is only indicated for the treatment of thoraco-lumbar and lumbar curves. The brace is informed by the principle that a constrained spine dynamics can achieve correction of a curve, by inverting the abnormal load distribution during growth. The practical application of the biomechanical principles of the PASB is achieved through two operative phases. A plaster cast phase precedes the brace application. At this stage, external forces are exerted to correct the deformity that is elongation, lateral deflection and derotation. This procedure allows obtaining transversal sections represented by asymmetric ellipsis. The finishing touch of the cast establishes the real geometry of the plastic brace. One or sometimes two casts, in relation to the curve rigidity, are manufactured before switching to the custom-made polypropylene orthosis of the second phase of treatment, [43,44]. Aulisa et al, 2009 reported Cobb angle and Pedriole torsion angle readings of the treated thoraco-lumbar and lumbar curves. The pre treatment Cobb mean value was 29,30 degrees ± 5,16 SD and the initial apical rotation 12.70 degrees ± 6,14 SD. The immediate Cobb correction was 14,67 ± 7,65 SD and the apical rotation correction at follow up 8,95 degrees ± 5,82. Overall curve correction was noted at 94% of patients, curve stabilization in 6% of patients, [44].

Conclusions

The treatment of adolescent idiopathic scoliosis (AIS) aims to stop the progression of the deformity and to improve the aesthetic appearance, trunk balance and quality of life [45]. Several centers in Europe offer full treatment, ranging from prevention (School screening), bracing with or without the use of exercises and surgery. The study and improvement of braces will ultimately improve the outcomes using the specific braces. As far as the conservative treatment with braces is concerned, there is a variety of outcomes reported in literature, [46,47,48,49,50]. Poor results can be due to poor bracing and this could be verified through in-brace radiographs to assess the obtained correction. Poor results can also be due to improper management of the patient, a factor that can ultimately influence compliance. The latter has not been yet sufficiently stressed in literature despite its critical role in the efficacy of any treatment [51,52]. Finally the documentation of all the critical aspects (history, design rationale, indications, biomechanics, outcomes and comparison between braces) of the European braces widely used will enable to draw attention to their pros and cons with the final aim not only to improve the braces, but also to offer a better conservative treatment for scoliosis.

Acknowledgements

We thank: Dr Jacques Chêneau and Dr Jean Claude de Mauroy for their consensus on the text, Dr Hans-Rudolf Weiss, Dr Stefano Nergini, and Prof. Lorenzo Aulisa and Dr Angelo Aulisa who read the text and made useful suggestions.

References

[1] Danielsson AJ, Hasserius R, Ohlin A, Nachemson AL. A prospective study of brace treatment versus observation alone in adolescent idiopathic scoliosis: a follow-up mean of 16 years after maturity. *Spine,* **32** (2007), 2198–2207.

[2] Danielsson AJ, Romberg K, Nachemson AL. Spinal range of motion, muscle endurance, and back pain and function at least 20 years after fusion or brace treatment for adolescent idiopathic scoliosis: a case-control study. *Spine,* **31** (2006), 275–283.

[3] Rowe DE. The Scoliosis Research Society Brace Manual. Milwaukee, WI: *Scoliosis Research Society*; (1998), 1–9.

[4] Weinstein SL, Dolan LA, Spratt KF, Peterson KK, Spoonamore MJ, Ponseti IV. Health and function of patients with untreated idiopathic scoliosis: a 50-year natural history study. *JAMA,* **289** (2003), 559–567.

[5] Weinstein SL, Ponseti IV. Curve progression in idiopathic scoliosis. *J Bone Joint Surg Am.* **65** (1983), 447–455.

[6] Weinstein SL, Zavala DC, Ponseti IV. Idiopathic scoliosis: longterm follow-up and prognosis in untreated patients. *J Bone Joint Surg Am.* **63** (1981), 702–712.

[7] Negrini S, Minozzi S, Bettany-Saltikov J, Zaina F, Chockalingam N, Grivas TB, Kotwicki T, Maruyama T, Romano M, Vasiliadis ES. Braces for idiopathic scoliosis in adolescents. *Cochrane Database of Systematic Reviews* (2009), Issue 1.

[8] Schiller JR, Thakur NA, Eberson CP Brace Management in Adolescent Idiopathic Scoliosis. *Clin Orthop Relat Res*. (2009) May 30. [Epub ahead of print] PMID: 19484317 .

[9] Kotwicki T, Cheneau J. Biomechanical action of a corrective brace on thoracic idiopathic scoliosis: Cheneau 2000 orthosis. *Disabil Rehabil Assist Technol*. **3(3),** (2008), 146-53.

[10] Kotwicki T, Cheneau J. Passive and active mechanisms of correction of thoracic idiopathic scoliosis with a rigid brace. *Stud Health Technol Inform*. **135** (2008), 320-326.

[11] Périé D, Sales De Gauzy J, Sévely A, Hobatho MC. In vivo geometrical evaluation of Cheneau-Toulouse-Munster brace effect on scoliotic spine using MRI method. *Clin Biomech (Bristol, Avon)*. **16(2)** (2001), 129-137.

[12] Hopf C, Heine J. Long-term results of the conservative treatment of scoliosis using the Chêneau brace. *Z Orthop Ihre Grenzgeb.* **123(3)** (1985), 312-322.

[13] Cinnella P. Muratore M. Testa E. Bondente P.G. The Treatment of adolescent idiopathic scoliosis with Cheneau brace: long term outcome. *Oral Presentation at Lyon 2009 SOSORT Meeting*.

[14] Manuel D Rigo, Mónica Villagrasa and Dino Gallo (2010) A specific scoliosis classification correlating with brace treatment: description and reliability. *Scoliosis* (2010) **5:1**

[15] Rigo M, Weiss HR 2008 The Chêneau concept of bracing-biomechanical aspects. *Stud Health Technol Inform*. **135** (2008), 303-319

[16] Rigo et al 2002 (Retrospective results in immature idiopathic scoliotic patients treated with a Chêneau brace. Rigo M, Quera-Salvá G, Puigdevall N, Martínez M. *Stud Health Technol Inform*. **88** (2002), 241-245.

[17] Rigo M and Gallo D. 2009 A new RSC brace design to treat single long thoracic scoliosis. Comparison of the in-brace correction in two groups treated with the new and the classical models. *Oral Presentation at Lyon 2009 SOSORT Meeting.*

[18] Hans-Rudolf Weiss, Mario Werkmann and Carola Stephan Correction effects of the ScoliOlogiC® „Cheneau light" brace inpatients with scoliosis. *Scoliosis* (2007), **2**:2 doi:10.1186/1748-7161-2-2

[19] Weiss HR: Best Practice in conservative scoliosis care. 3rd. edition, Pflaum, Munich, 2010.

[20] Weiss HR, Rigo M. The chêneau concept of bracing--actual standards. *Stud Health Technol Inform*. **135** (2008), 291-302.
[21] de Mauroy JC, Lecante C, Barral F, Daureu D, Gualerzi S, Gagliano R. The Lyon brace. *Disabil Rehabil Assist Technol*. **3(3)** (2008), 139-145.
[22] de Mauroy JC, Fender P, Tato B, Lusenti P, Ferracane G. Lyon brace. *Stud Health Technol Inform*. **135** (2008), 327-340.
[23] Antoniou D, Valavanis J, Zachariou C, Smyrnis P. 1986 "Dynamic Derotation Brace (DDB). A new aspect for the conservative treatment of Idiopathic Scoliosis" (1986), *Presentation in 21st common meeting of SRS and BSS*.
[24] Valavanis J, Bountis A, Zachariou C, Kokkonis D, Anagnostou D, Giahos D, Daskalakis E. Three-Dimensional Brace Treatment for Idiopathic Scoliosis. In: *Three Dimensional Analysis of Spinal Deformities* M D'Amico et al (Eds.) IOS Press, (1995), 337-341.
[25] Andoniou D, Valavanis J et al: The effectiveness of our bracing system in the conservative treatment of idiopathic scoliosis. *J Bone Joint Surg*, **74-B**. Suppl, I, (1992), 86.
[26] Grivas TB, Vasiliadis E, Chatziargiropoulos T, Polyzois VD, Gatos K. The effect of a modified Boston brace with anti-rotatory blades on the progression of curves in idiopathic scoliosis: aetiologic implications. *Pediatr Rehabil.* **6(3-4)** (2003), 237-242.
[27] Grivas TB, Vasiliadis ES. Cosmetic outcome after conservative treatment of idiopathic scoliosis with a dynamic derotation brace. *Stud Health Technol Inform*. **135** (2008), 387-392.
[28] Vasiliadis E, Grivas TB. Quality of life after conservative treatment of adolescent idiopathic scoliosis. *Stud Health Technol Inform*. **135** (2008), 409-413.
[29] Vasiliadis E, Grivas TB, Gkoltsiou K. Development and preliminary validation of Brace Questionnaire (BrQ): a new instrument for measuring quality of life of brace treated scoliotics. *Scoliosis*. (2006) May 20;**1**:7.
[30] Vasiliadis E, Grivas TB, Savvidou O, Triantafyllopoulos G. The influence of brace on quality of life of adolescents with idiopathic scoliosis. *Stud Health Technol Inform*. **123** (2006), 352-356.
[31] Veldhuizen AG. Idiopathic Scoliosis. A Biomechanical and Functional Anatomical Study. *Thesis, University of Groningen.* Groningen, the Netherlands: (1985).
[32] Veldhuizen AG, Cheung J, Bulthuis GJ, Nijenbanning G. A new orthotic device in the non-operative treatment of idiopathic scoliosis. *Medical Engineering & Physics,* **24** (2002), 209–218.
[33] Bulthuis GJ , Veldhuizen AG, Z Nijenbanning G. Clinical effect of continuous corrective force delivery in the non-operative treatment of idiopathic scoliosis: a prospective cohort study of the triac-brace *Eur Spine J* **17** (2008), 231–239.
[34] Zeh A, Planert M, Klimas S, Hein W, Wohlrab D The flexible Triac™-Brace for conservative treatment of idiopathic scoliosis. An alternative treatment option ? *Acta Orthop. Belg*, **74** (2008), 512-521.
[35] Negrini S, Marchini G. Efficacy of the symmetric, patient-oriented, rigid, three-dimensional, active (SPoRT) concept of bracing for scoliosis: a prospective study of the Sforzesco versus Lyon brace. *Eura Medicophys.* **43(2)** (2007), 171- 181.
[36] Negrini S, Atanasio S, Negrini F, Zaina F, Marchini G. The Sforzesco brace can replace cast in the correction of adolescent idiopathic scoliosis: A controlled prospective cohort study. *Scoliosis*. (2008) Oct **31;3**:15.
[37] Negrini S, Atanasio S, Fusco C and Zaina F. Efficacy of bracing in worst cases (over 45°) end-growth results of a retrospective case-series. *Scoliosis* (2009), **4**(Suppl 2):O50
[38] Negrini S, Atanasio S, Fusco C and Zaina F. Efficacy of bracing immediately after the end of growth: final results of a retrospective case series. *Scoliosis* (2009), **4**(Suppl 2):O49.
[39] Negrini S, Atanasio S, Fusco C and Zaina F. Efficacy of conservative treatment of adolescent idiopathic scoliosis: end-growth results respecting SRS and SOSORT criteria. *Scoliosis,* (2009), **4**(Suppl 2):O48.
[40] Negrini S, Atanasio S, Zaina F, Romano M, Parzini S, Negrini A. End-growth results of bracing and exercises for adolescent idiopathic scoliosis. Prospective worst-case analysis. Stud Health Technol Inform. **135** (2008), 395-408.
[41] Negrini S, Atanasio S, Fusco C, Zaina F. Effectiveness of complete conservative treatment for adolescent idiopathic scoliosis (bracing and exercises) based on SOSORT management criteria: results according to the SRS criteria for bracing studies - SOSORT Award 2009 Winner. *Scoliosis*. (2009) Sep **4;4**:19.
[42] Zaina F, Negrini S, Fusco C, Atanasio S. How to improve aesthetics in patients with Adolescent Idiopathic Scoliosis (AIS): a SPoRT brace treatment according to SOSORT management criteria. *Scoliosis*. (2009) Sep **1;4**:18.
[43] Di Benedetto A, Vinciguerra A, Pennestri' E, Aulisa L: Biomechanics of Scoliosis Using a New Type of Brace. *Proceedings of the 8th Canadian Congress of Applied Mechanics*, Moncton, N.-B., Canada, 7-12 June, (1981), 785-786.
[44] Aulisa AG, Guzzanti V, Galli M, Perisano C, Falciglia F and Aulisa L. Treatment of thoraco-lumbar curves in adolescent females affected by idiopathic scoliosis with a progressive action short brace (PASB): assessment of results according to the SRS committee on bracing and nonoperative management standardization criteria *Scoliosis,* (2009), **4**:21 doi: 10.1186/1748-7161-4-21.
[45] Negrini S, Grivas TB, Kotwicki T, Maruyama T, Rigo M, Weiss HR, the members of the Scientific society On Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT): Why do we treat adolescent idiopathic scoliosis? What we want to obtain and to avoid for our patients. SOSORT 2005 Consensus paper. *Scoliosis,* (2006), **1**:4.
[46] Rigo M, Reiter C, Weiss HR: Effect of conservative management on the prevalence of surgery in patients with adolescent idiopathic scoliosis. *Pediatr Rehabil* (2003), **6(3–4)**:209-214.

[47] Maruyama T, Kitagawa T, Takeshita K, Mochizuki K, Nakamura K: Conservative treatment for adolescent idiopathic scoliosis: can it reduce the incidence of surgical treatment? *Pediatr Rehabil* **6(3–4),** (2003), 215-219.
[48] Negrini S, Atanasio S, Zaina F, Romano M, Parzini S, Negrini A: Endgrowth results of bracing and exercises for adolescent idiopathic scoliosis. Prospective worst-case analysis. *Stud Health Technol Inform* **135** (2008), 395- 408.
[49] Weiss HR, Goodall D: The treatment of adolescent idiopathic scoliosis (AIS) according to present evidence. A systematic review. *Eur J Phys Rehabil Med* **44(2)** (2008), 177-193.
[50] Dolan LA, Weinstein SL: Surgical rates after observation and bracing for adolescent idiopathic scoliosis: an evidencebased review. *Spine*, **32**(19 Suppl) (2007), S91-S100.
[51] Landauer F, Wimmer C, Behensky H: Estimating the final outcome of brace treatment for idiopathic thoracic scoliosis at 6-month follow-up. *Pediatr Rehabil* **6(3–4)** (2003), 201-207.
[52] Negrini S, Grivas TB, Kotwicki T, Rigo M, Zaina F and the international Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT). Guidelines on "Standards of management of idiopathic scoliosis with corrective braces in everyday clinics and in clinical research": SOSORT Consensus 2008. *Scoliosis* (2009), **4**:2 doi:10.1186/1748-7161-4-2.

Figure 1. The Chêneau Brace

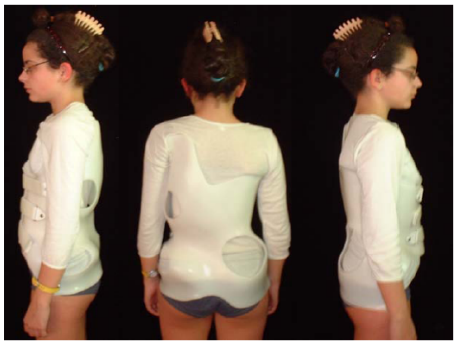

Figure 2. The RCS Brace

Figure 3. The *ScoliOlogiC® "Chêneau light"* Brace

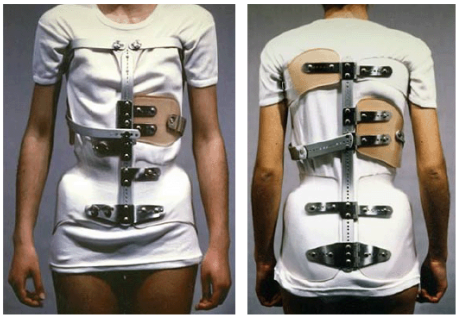

Figure 4. The Lyonnaise Brace

Figure 5. The DDB Brace

Figure 5. The TriaC brace

Figure 7. The Sforzesco brace

Figure 8. The Progressive Action Short Brace (PASB)