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A REVIEW OF INNOVATIVE TYPES OF BRACES FOR ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

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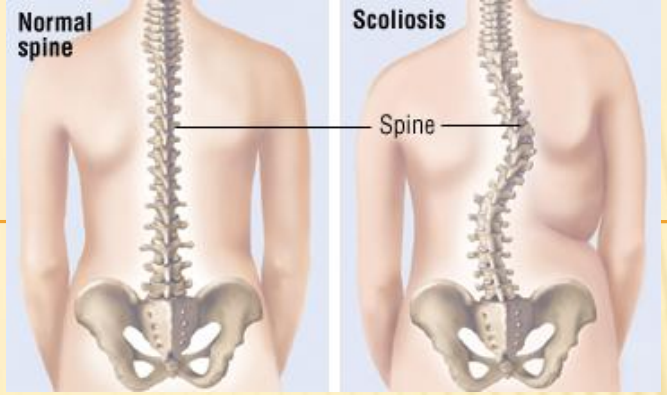
INTRODUCTION



Picture from: http://search.credoreference.com.ezproxy.lb.polyu.edu.hk/content/entry/hhphealth/scoliosis/0

What is scoiliosis?

- Three-dimensional deformity of the spine and trunk
- 80% of scoliosis cases are idiopathic scoliosis - the cause is unknown
- Adolescent idiopathic scoliosis (AIS) is the most common type of scoliosis - the age of onset is between 10 and 16 years old

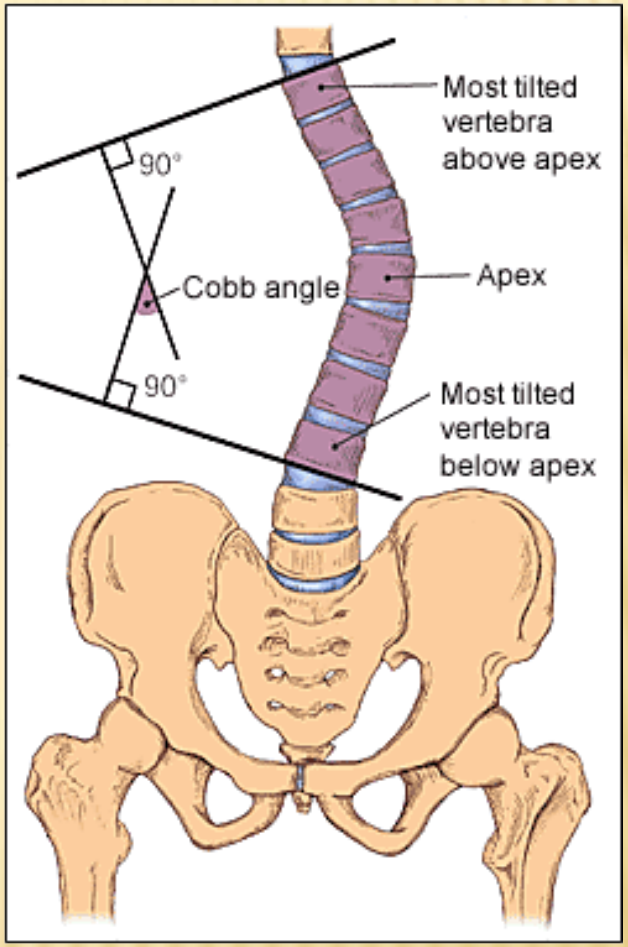
•Negrini, S., Aulisa, A.G., Aulisa, L., Circo, A.B., de Mauroy, J.C., Durmala, J., Grivas, T.B., Knott, P., Kotwicki, T., Maruyama, T. and Minozzi, S., 2012. 2011 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis*, *7*(1), p.3.

•Negrini, S., Minozzi, S., Bettany-Saltikov, J., Chockalingam, N., Grivas, T.B., Kotwicki, T., Maruyama, T., Romano, M. and Zaina, F., 2015. Braces for idiopathic scoliosis in adolescents. *Cochrane Database of Systematic Reviews*, *6*.

•Weinstein, S.L., Dolan, L.A., Cheng, J.C., Danielsson, A. and Morcuende, J.A., 2008. Adolescent idiopathic scoliosis. *The Lancet*, *371*(9623), pp.1527-1537.

INTRODUCTION

- A diagnosis of scoliosis is confirmed when the Cobb angle is 10 degrees or greater, which is measured through a standard radiographic examination



Picture from: http://www.mullumbimbychiropractic.com.au/common-problems/scoliosis

INTRODUCTION

Treatment of scoliosis

- Depends on type of curve, age and severity of spinal curvature
- Surgery: > 40-50 degrees
- Brace: Usually between 20 and 30 degrees
- Observation: < 20 degrees
- Bracing is the most commonly used non-invasive treatment

•Trobisch, P., Suess, O. and Schwab, F., 2010. Idiopathic scoliosis. *Deutsches Ärzteblatt International*, *107*(49), p.875.
•Lonstein, J.E., 2006. Scoliosis: surgical versus nonsurgical treatment. *Clinical orthopaedics and related research*, *443*, pp.248-259.
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•Richards, B.S., Bernstein, R.M., D'Amato, C.R. and Thompson, G.H., 2005. Standardization of criteria for adolescent idiopathic scoliosis brace studies: SRS Committee on Bracing and Nonoperative Management. *Spine*, *30*(18), pp.2068-2075.

INTRODUCTION

- Bracing is the application of external corrective forces onto the spine and trunk
- It can be rigid or flexible

Example of rigid brace : Milwaukee brace

Picture from: http://www.scoliosisjournal.com/content/2/1/19/figure/F2

Example of flexible brace: SpineCor®

Picture from: http://www.spinecor.org/scoliosistreatment.htm

•Negrini, S., Minozzi, S., Bettany-Saltikov, J., Chockalingam, N., Grivas, T.B., Kotwicki, T., Maruyama, T., Romano, M. and Zaina, F. (2015) 'Braces for idiopathic scoliosis in adolescents', *Cochrane Database of Systematic Reviews*, *6*.

INTRODUCTION

Problems of conventional rigid braces

- They are made of rigid components such as metals and rigid plastics causing:

→Heavy, non-breathable and uncomfortable

→Difficult to move

→Difficult to wear and take off

→Bulky and awkward appearances

→Lower self-esteem, more fatigue and lower compliance

Milwaukee Brace

Pictures from: http://scoliosisbrace.ca/spinecor-brace-for-children/

TLSO Brace

•Rivett, L., Rothberg, A., Stewart, A. and Berkowitz, R., 2009. The relationship between quality of life and compliance to a brace protocol in adolescents with idiopathic scoliosis: a comparative study. *BMC musculoskeletal disorders*, *10*(1), p.5.

•Park, J.H., Stegall, P. and Agrawal, S.K., 2015, May. Dynamic brace for correction of abnormal postures of the human spine. In *Robotics and Automation (ICRA), 2015 IEEE International Conference on* (pp. 5922-5927). IEEE.

INTRODUCTION

- Some existing flexible braces are designed to overcome the limitations of rigid braces
- They are made of textiles combined with plastics or metals

SpineCor brace

Picture from: http://www.spinecor.com/ForProfessionals/SpineCorDynamicCorrectiveBrace.aspx

TriaC brace

Picture from: http://www.oandp.com/articles/2007-05_15.asp

INTRODUCTION

Advantages of existing flexible braces:	Disadvantages of existing flexible braces:
appearance → More acceptable for teenagers and higher compliance	

Objective:
Review of the design features and materials used for the fabrication of innovative types of braces

•Coillard, C., Vachon, V., Circo, A.B., Beauséjour, M. and Rivard, C.H., 2007. Effectiveness of the SpineCor brace based on the new standardized criteria proposed by the scoliosis research society for adolescent idiopathic scoliosis. *Journal of Pediatric Orthopaedics*, *27*(4), pp.375-379.

•Wong, M.S., Cheng, J.C., Lam, T.P., Ng, B.K., Sin, S.W., Lee-Shum, S.L., Chow, D.H. and Tam, S.Y., 2008. The effect of rigid versus flexible spinal orthosis on the clinical efficacy and acceptance of the patients with adolescent idiopathic scoliosis. *Spine*, *33*(12), pp.1360-1365.

•Veldhuizen, A.G., Cheung, J., Bulthuis, G.J. and Nijenbanning, G., 2002. A new orthotic device in the non-operative treatment of idiopathic scoliosis. *Medical engineering & physics*, *24*(3), pp.209-218.

METHOD

- Search engines: **PubMed**, **BioMed Central**, **ResearchGate** and **SAGE**
- Search strings:

"**innovative brace**" + "**scoliosis**"

"**smart brace**"+ "**scoliosis**"

"**comfort brace**"+ "**scoliosis**"

- Publication date: between **1st January 2005** and **4th December 2015**
- Language: **English**

RESULTS

Search strings	No. of related articles
“**innovative brace**” + “**scoliosis**”	**4** (3 rigid braces and 1 flexible brace)
“**smart brace**”+ “**scoliosis**”	**2** (1 rigid brace and 1 flexible brace)
“comfort brace”+ “scoliosis”	**6** (4 rigid brace and 2 flexible brace)
Total	**12**

→5 of them involve the improvement of the comfort and compliance of treatment for AIS
→3 are rigid braces and 2 are flexible braces
→ScoliOlogiC® Chêneau light™ brace,
Gensingen brace™, CMCR brace, Spinealite™ and tailor-made posture correction girdle

DEVELOPMENT OF INNOVATIVE TYPES OF BRACES

ScoliOlogiC® Chêneau light™ brace

Purpose: improve the quality of life of AIS patients

→ lighter, finer and easier to wear

- Components: four polyethylene shells, two uprights and straps with attachments
- Paddings→increase the wear comfort and increase the area that induces pressure

Advantages:

→Light brace since fewer materials are used

→Open spaces are designed for corrective movement

→Pressure sores caused by compression effects are avoided

Pictures from:'Brace Technology' Thematic Series - The ScoliOlogiC® Chêneau light™ brace in the treatment of scoliosis, p.19

• Weiss, H.R. and Werkmann, M. (2010) 'Brace Technology Thematic Series - The ScoliOlogiC® Chêneau light™ brace in the treatment of scoliosis', *Scoliosis*, 5 pp.19.

DEVELOPMENT OF INNOVATIVE TYPES OF BRACES

Gensingen brace™

- The purpose and principle are similar to ScoliOlogiC® Chêneau light™ brace

Differences between them:

→ Gensingen brace™ is based on the precise arrangement of pressure zones and associated open spaces

→ Gensingen brace™ is formed by a single polyethylene shell and the straps with attachments

→ ScoliOlogiC® Chêneau light™ brace is created by using many different parts

Picture from: 'Brace technology' thematic series-the Gensingen brace™ in the treatment of scoliosis, p.5.

• Weiss, H.R. (2010) 'Brace technology thematic series-the Gensingen brace™ in the treatment of scoliosis', *Scoliosis*, *5*(1), pp.1-17.

DEVELOPMENT OF INNOVATIVE TYPES OF BRACES

CMCR brace (monoshell carbon brace respecting breathing)

- inspired by wear comfort, lightness in weight, aesthetics and respiratory capacity
- based on the corrective principle of the Lyon brace which consists of brace pads located on humps
- made of polyethylene and carbon with adjustable and mobile supports

Picture from: 'Vital capacity evolution in patients treated with the CMCR brace: statistical analysis of 90 scoliotic patients treated with the CMCR brace', p.19.

Advantages:

→The mobility provides permanent pressure and more opportunities to orient forces

→The correction is achieved without blocking chest movement→ preserves respiratory capacity

→An anterior opening allows patients to easily put the brace on

• Bernard, J.C., Deceuninck, J. and Kohn, C. (2011) 'Vital capacity evolution in patients treated with the CMCR brace: statistical analysis of 90 scoliotic patients treated with the CMCR brace'. *Scoliosis*. *6*(1). pp.19.

DEVELOPMENT OF INNOVATIVE TYPES OF BRACES

Spinealite™

- **Purpose:** solve the existing problems of soft braces in the market → easier to adjust and use
- mainly consists of elastic ribbon materials
- 3D system consists of pelvic girdle correction, shifting of the shoulder and pelvic girdles against one another, spiral shoulder girdle correction and correction of the sagittal profile

Advantages:

→Simple construction, easier to wear and adjust

→Materials are durable → do not lose the tension force after long time wear

→Corrective forces applied with limited freedom of movement → maximize the corrective effects

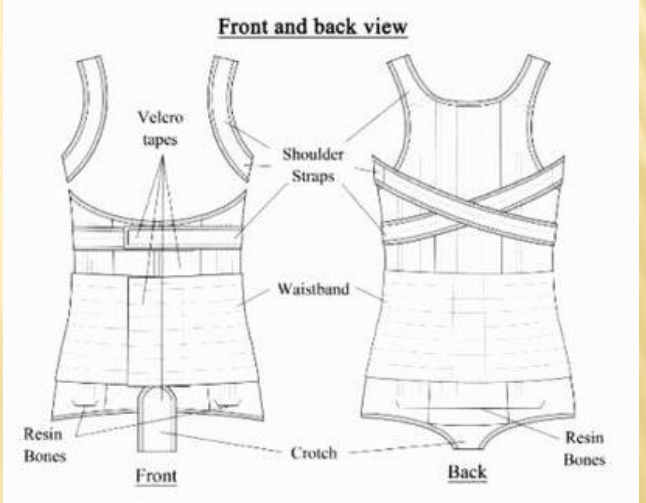
Picture from: 'Soft braces in the treatment of Adolescent Idiopathic Scoliosis (AIS)–Review of the literature and description of a new approach', p.11.

• Weiss, H.R. and Werkmann, M. (2012) 'Soft braces in the treatment of Adolescent Idiopathic Scoliosis (AIS)–Review of the literature and description of a new approach', *Scoliosis*, *7*(1), pp.11.

DEVELOPMENT OF INNOVATIVE TYPES OF BRACES

Tailor-made posture correction girdle

- **Purpose:** reduce imbalance of the waist and pelvis with a more natural look and better wear comfort
- mainly made of warp-knitted fabrics (tricot, satinette and powernet)
- resin bones and EVA foam paddings → supportive and point pressure forces
- elastic shoulder straps and waistband → additional corrective forces



Pictures from: 'Effects of a tailor-made girdle on posture of adolescents with early scoliosis', p.1234-1246.

Advantages

→Natural appearance (similar to underwear with a vest-like design)

→Breathable and comfortable

→Easy to adjust and wear

• Liu, P.Y., Yip, J., Yick, K.L., Yuen, C.W.M., Tse, C.Y., Ng, S.P. and Law, D. (2015) 'Effects of a tailor-made girdle on posture of adolescents with early scoliosis', *Textile Research Journal*, *85*(12), pp.1234-1246.

Comparison of the innovative types of rigid braces

	ScoliOlogiC® Chêneau light™ brace	**Gensingen brace™**	**CMCR brace**
Invention period	- Late 2000s	- Late 2000s	- Late 2000s
Primary materials used	- Four polyethylene shells, two uprights and straps with attachments	- Single polyethylene shell, straps with attachments	- Polyethylene base with carbon blade
Advantages	- Easier to adjust for all possible curve patterns and trunk sizes of patients - Quicker to produce - Lighter, finer and easier to wear	- Easier to adjust for all possible curve patterns and trunk sizes of patients - Quicker to produce - More comfortable to wear	- Able to provide permanent pressure and orient forces - Able to preserve respiratory capacity - Easier to wear
Effectiveness	- 38°(at the beginning of treatment) reduced to 19° (after 24 months of consistently wearing the brace)	- 43° (at the beginning of treatment) reduced to 23° (after 6 months of consistently wearing the brace)	- 24.1°(at the beginning of treatment) reduced to 20.2° (at the definitive brace removal)

Comparison of the innovative types of flexible braces

	Spinealite™	**Tailor-made posture correction girdle**
Invention period	- 2010s	- 2010s
Corrective mechanism	- 3D system of postural corrections	- 3-point pressure system
Primary materials used	- Elastic ribbon materials	- Warp-knitted fabrics, resin bones and EVA foams
Advantages	- Easier to wear and adjust - More durable - More natural appearance	- Easier to wear and adjust - More natural appearance - More breathable and comfortable
Effectiveness	- 27° (at the beginning of treatment) reduced to −16° (in brace correction)	- 19° (at the beginning of treatment) reduced to 14° (after 6 months of daytime treatment)

CONCLUSION

- A number of innovative bracing designs have been proposed to increase wear comfort and provide good corrective effects
- Rigid braces: use materials that are lighter in weight, or reduce the amount of material used → reduce body movement restrictions and weight of the brace
- Flexible braces: use elastic materials, foams or textiles such as warp knitted fabrics that allows greater body movement, and the more natural appearance can be more acceptable by adolescents
- Physiological and psychological comforts of patients are important in improving compliance and the corrective effects of bracing treatment

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THE END
THANK YOU
Q&A