

A Case Report - Outcome of Bracing and Physiotherapeutic Scoliosis-Specific Exercises in an Adolescent with an Idiopathic Thoracic Scoliosis in Surgical Range

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Abstract

Background: Adolescent idiopathic scoliosis (AIS) patients with a Cobb angle $>45^\circ$ are generally referred for surgery, especially in Asia. Physicians do not typically prescribe braces or physiotherapeutic scoliosis-specific exercises for such cases.

Case Presentation: We described a case of right thoracic scoliosis with a Cobb angle of 51° . The parents refused surgery and opted for conservative treatments. We braced the pre-menarchal patient at the age of 10, with Risser at 0, and coached her on exercises, which include traditional Schroth, the Schroth Best Practice, the dynamic neuromuscular stabilization (DNS), and the Pilates exercises. The patient has been very compliant with the brace-wear and the exercises.

The treatment's outcome was good. The Cobb angle was reduced to 29.5° , the ATR from 15° to 1° , and the right truncal shift was reduced. The spine became more balanced. The reduction in the Cobb angle to below 30° reduced the possibility of the curve being progressive in adulthood. Also, the improved aesthetics positively affect her confidence.

Conclusion: The case illustrates that bracing and physiotherapeutic scoliosis-specific exercise (PSSE) may be indicated in patients who opt not to have surgery. We cannot generalize the outcome to all AIS patients with a curve $>45^\circ$. However, we opined that rigorous bracing and PSSE therapy should be tried on adolescents with severe scoliosis prior to surgery.

Keywords: Adolescent idiopathic scoliosis, AIS, Chêneau brace, Brace, Scoliosis-specific exercises, PSSE

Background

Adolescent idiopathic scoliosis (AIS) afflicts around 2-3% of the population. It refers to lateral curvatures of the spine $\geq 10^\circ$ in adolescents aged between 10-18 years. Depending on the magnitude of the curvatures and the remaining growth, treatment consists of observation, physiotherapeutic scoliosis-specific exercises, bracing, and surgery [1]. Bracing is indicated for growing patients with a Cobb angle larger than $20-25^\circ$ and less than 45° . Patients with Cobb angle $\geq 45^\circ-50^\circ$ are generally referred for surgery [1], especially in Thailand.

Despite the above guidelines, some parents of AIS patients with curves in the surgical range have chosen conservative

treatments over surgery. This decision, often made out of concern for their child's well-being, is supported by studies showing that only curves over 80° are associated with pulmonary symptoms [2] and that bracing can stabilize and even reduce some curves [3-5], including those in the surgical range [3,5]. We present a case of a 10-year-old Thai girl with a right thoracic scoliosis measuring 51° , whose parents, in consultation with us, chose bracing over surgery.

We report the outcome of the management and suggest that bracing and scoliosis-specific exercises should be tried in growing adolescents with severe scoliosis before surgical consideration. We obtained her parents' consent and ensured her anonymity regarding all the data and images.

Case Presentation

The patient, a girl, was first consulted for scoliosis at 10 in 2019. Her aunt first noted the trunk imbalance when the patient spoke in front of a class. Subsequent examination by her mother confirmed that the girl and her elder sister had uneven shoulders and truncal imbalance.

She consulted an orthopedic surgeon in Bangkok, Thailand, in May 2019. The patient's posteroanterior erect full spine radiograph showed a right thoracic scoliosis, with the apex at T10/11. The Cobb angle was 51°, with the upper and lower end vertebrae at T7 and L2, respectively. The left pelvic shift was evident. There was a marked right truncal shift. Yet, we could not measure the distance between the C7 spinous process and the central sacral line (CSL), as the radiograph was not calibrated. Her orthopedic surgeon recommended that she wear a brace and have surgery when she was 12. After meeting the orthotic team and finding that a plaster cast was required to fabricate the Boston brace and having seen the brace, the patient's parents opted for the Chêneau brace and consulted the first author.

She was first seen in the clinic in June 2019, when she was pre-menarchal. Physical examination showed that the angle of trunk rotation (ATR) was 15°. The standing and sitting heights were 151 cm. and 125 cm, respectively. She weighed 46 kg. A left pelvis shift was evident.

The girl had no other significant symptoms. Her parents first noticed that she grew very fast in height between the ages of 8-9 years. The radiograph of the left wrist then showed that the bone age was two years older than her chronological age. Worrying that the patient might stop growing soon, the patient consulted a medical general practitioner in 2018 at 9. She was advised to take 1L of milk per day, consume more vegetables, and engage in more sports activities, together with daily supplements of 1250 mg calcium carbonate, a multivitamin, and 11 mg zinc sulphate before meals to encourage continuous growth. The patient was followed up every three months by her general practitioner. She is omnivorous, but she did not eat vegetables.

As the parents of the patient refused the option of surgery, the patient was prescribed a Chêneau type of brace and was treated by physiotherapeutic scoliosis-specific exercises (PSSE) and dynamic neuromuscular stabilization (DNS) exercises. The intervention includes a modified Chêneau brace and PSSE. The brace was custom-made, using a structured scanner and an O&P (orthotic and prosthetics) specific CAD software, with corrections based on the Schroth exercises principle. The brace was checked fortnightly in the first two months. An in-brace X-ray was performed 8 weeks after fitting. Thereafter, the brace was checked monthly for the first six months to ensure that the patient wore it correctly and that the pressure points and voids were in the proper levels and locations. The brace was

modified in case the correction was not optimal. The patient was then seen once every 2-3 months, and the brace was slightly modified when needed to ensure that proper pressure was still exerted at the correct level and position. When the sitting height increased by 3-4 cm or the patient grew in size, making the brace too tight, she was prescribed a new brace.

For the PSSE, the patient was guided to understand the correction principles. She was first instructed to perform corrective activities of daily living (ADL) in sitting and standing positions. Exercises with increasing difficulties were gradually introduced. After learning rotational angular breathing (RAB), she was taught the sitting and the standing PSSE based on Schroth's Best Practice [6]. After the first three months, the patient was taught the traditional Schroth exercises, including the shoulder counter traction exercises in lying, prone, and sitting positions to strengthen the shoulder girdle muscles. Also, the patient was instructed to perform the isometric exercises in a prone position with traction, St. Andrew's Cross exercise, and exercises using two poles [7]. DNS exercises were introduced to strengthen the core muscles and elongate the spine; they include the 3-month-old baby postures in supine, prone, and side-lying positions [8]. In the first two years, the patient exercised for an hour weekly under supervision. In the subsequent year, the frequency of supervised exercises was reduced to twice a month. She was seen once every month thereafter. In combination with the supervised exercise sessions, the patient was advised to perform the exercises at home for half an hour daily.

Bracing commenced on 3 July 2019; the prescribed wearing time was 22 hours daily. Concomitantly, she performed the PSSE under supervision. All the exercises were performed with the brace off, with her mother's attendance. Whilst exercising, the family was counseled concerning the scoliosis treatment.

During the first three days of wearing the brace, she complained of discomfort but not pain. She never complained again, which was challenging for us as she did not speak up. We had to check the pressure points to ensure that the brace pressure was placed correctly. Fortunately, despite the warm and humid weather, she never experienced skin rashes.

Two months after the bracing and exercise intervention, the patient was radiographed in-brace on 1 September 2019. The in-brace Cobb angle was reduced to 20.3° (**Figure 1**), making an in-brace correction of 60.2%. Physical examination showed axial trunk rotation (ATR) of 4°. The brace was adjusted to improve the shoulder level imbalance.

The patient self-declared that she complied with the bracing and the exercises. In the follow-up examination in April 2020, nine months after bracing, her ATR further reduced, measuring 2.5°–3.0° off-brace. A 24-hour out-of-the-brace erect PA full spine radiograph showed that her out-of-the-brace Cobb angle was 35.7°.

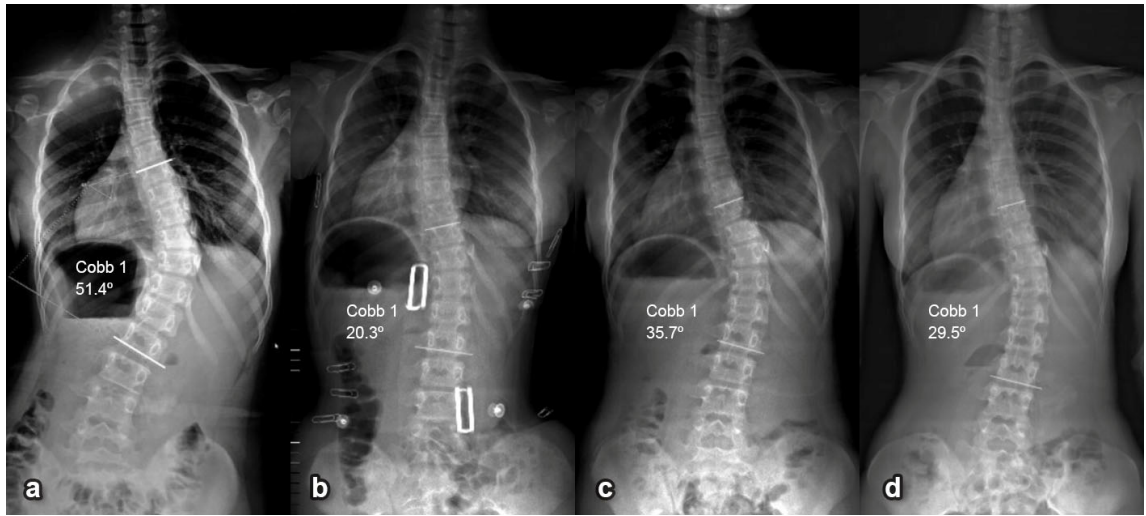


Figure 1. Cobb angles change. (a) Posteroanterior (PA) standing full spine radiograph when the patient was first seen in June 2019. (b) The in-brace PA spine radiograph - the Cobb angle reduced from 51° to 20.3°, representing an in-brace correction of 60.2%. (c) The out-of-the-brace PA full spine of the patient in May 2020 showed a Cobb angle of 35.7°, which was reduced to 29.5° in February 2025 (d).

As her standing and sitting height increased to 157 cm and 130 cm, respectively, and her weight increased to 51 kg, she was prescribed a new brace. In May 2021, an out-of-the-brace radiograph showed the Cobb angle at 34.3° (Figure 2), with the ATR at 3°.

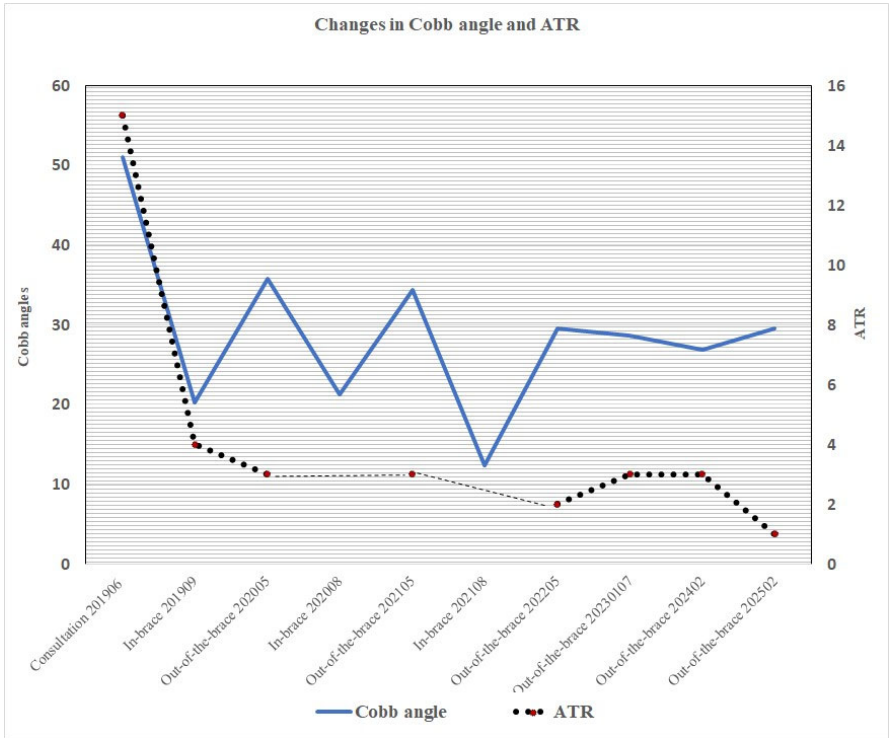


Figure 2. The changes in Cobb angle and ATR during the treatment are evident, and the in-brace Cobb angles are markedly reduced with bracing. Also, there is a significant reduction in ATR.

During COVID, the clinic was closed in March and April 2020. The clinic could not provide treatment; the patient continued to perform the exercises at home. The home exercises remained similar, except for the addition of Pilates mat exercises, which include movements such as curl-up, bridging with marching, toe tap, bear pose, opposite arms and legs reach, windshield wiper, and side-lying banana, etc, to improve her scapular strength, stability, and spinal elongation.

In mid-April 2020, she resumed performing PSSE in the clinic. Throughout 2021, she visited the clinic for exercise treatment approximately twice a month.

In May 2022, a year after wearing the third brace, her out-of-the-brace Cobb angle was 29.5°, and the ATR further stabilized at 2°. As the curve and her growth stabilized, with no significant increase in weight, we decided not to make a new brace.

In August 2022, she was in Risser stage 4 based on the US classification. We reduced her brace-wearing time to 20 hours per day (a decrease of 2 hours) and her PSSE treatment frequency to approximately once a month.

In January 2023, we again radiographed the patient out-of-brace. The Cobb angle stabilized at 28.6°, with ATR at 3°. Brace-wearing time was further reduced by two hours every three months.

In February 2024, when she was 15, another radiograph was taken three days after being out-of-brace. The Cobb angle remained stable at 26.8°, with ATR at 3° (**Figure 2**). As her Risser sign approached 5, we reduced the brace-wearing time to 12 hours daily. Also, we decreased the exercise treatment frequency to approximately once every six weeks while monitoring the ATR. When last seen in February 2025, she wore her brace only during sleep. Her ATR fell to 1°, and her right truncal shift markedly improved compared to the initial consultation, with a reduction in left hip prominence (**Figure 3**). She was in Risser 5, and the two days off-the-brace, Cobb's angle was 29.5°.

Discussion

We found that using a modified Chêneau brace and PSSE and DNS exercises improves the severe right thoracic curve in a girl aged 10 with Risser stage 0. The Cobb curve reduced significantly from 51° to 29.5°. The improvement was 42% compared with the initial presentation. What is more important, perhaps, is that at the end of the treatment, the out-of-brace spine radiograph showed that the thoracic curve is reduced to 29.5°, which is well below 30°, which is associated with curve progression in adulthood [9]. The improvement greatly relieved the parents and the patient, eliminating their concerns about surgery.

Also, the patient's aesthetics improved; the thoracic hump reduced, with the ATR reducing from 15° to 1°, and the left hip prominence decreased. The changes in coronal shift (horizontal distance between the central sacral line to the spinous process of C7) were not measured as the initial PA full spine radiograph did not have calibration. The improvement in aesthetics is essential as scoliosis specialists regard it as the foremost objective of scoliosis treatment [3]. Improvement of aesthetics will likely improve the patient's self-confidence, positively impacting her personality and future career.

The thoracic curve's improvement was consistent with previous studies findings, which showed that bracing could effectively treat AIS [10] and reduce some curves over 45° [3,5,11]. In a prospective study, Karavidas *et al.* (2022) reported that treatment with a brace and PSSE avoided curve progression by more than 5° in 88.5% of AIS patients with curves between 25° and 40°. However, the study did not include patients with curves above 40° [10]. Studies targeted curves above 45° were few [3,5,11-13] as Scoliosis Research Society (SRS) and SOSORT do not recommend brace treatment for curves more than 45° [10]. Negrini *et al.* (2011) reported improvement in curves in 71% in 28 patients (24F, 4M) with an average age of 14.2 and initial Cobb angle of 49.4°; they treated the curves by Risser cast, Lyon braces or Sforzesco braces, and SEAS (Scientific Exercises Approach to Scoliosis),

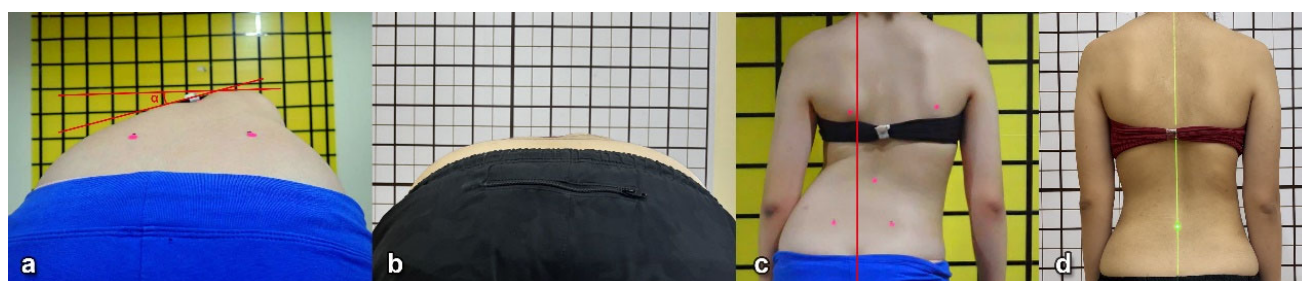


Figure 3. Improvement in the angle of trunk rotation (ATR) and truncal shift. The ATR during the first consultation in June 2019 (a) and at the end of the treatment (b) demonstrates significant improvement. The right rib hump was markedly reduced. The posterior view of the patient in June 2019 before (c) and after intervention (d) in February 2025 shows a marked reduction in the right trunk shift with decreased left hip prominence.

which is a form of scoliosis-specific exercises. The reduction in the thoracic curve averaged 7.8° [3]. Similar findings were reported by Lusini *et al.* (2014) and Aulisa *et al.* (2019). They braced patients with scoliosis in the surgical range and reported an improvement rate of 53.8% and 78%, respectively [5,11]. They used different braces and methods. Lusini *et al.* (2014) used Risser casts, Sforzesco braces, and SEAS exercises. Aulisa *et al.* (2019) used PASB (progressive action short brace) to treat lumbar and thoracolumbar curves and Lyon brace to treat thoracic and double curves [5]. They did not prescribe any PSSE. The other brace studies, however, did not report an improvement rate as high [12,13]. Zhu *et al.* (2017) used Boston or Milwaukee braces and physical exercises to treat AIS with Cobb angles between 40-50° and reported an improvement rate of 13% [12]. Similarly, Razeghinezhad *et al.* (2021), using Milwaukee braces for treatment, found that only 18% of the 60 AIS patients with Cobb angle between 40-55° improved [13].

Also, our case improved spinal balance and, thus, the aesthetics. The right truncal shift was reduced. Again, the findings concurred with the reports by Negrini *et al.* (2011), who showed that brace and SEAS treatments improve the patient's aesthetic index (AI). AI is based on a three-point scale, evaluating the asymmetry of the shoulders, scapulae, and waist [3]. Further, we found a reduction in ATR, a finding consistent with results from previous studies [3,5,11].

The marked improvement of the curve in our case may be attributed to many factors, including the low Risser stage, the flexibility of the curve, the relatively high in-brace correction of 60.2%, and the compliance of the patient in wearing the brace and performing the PSSE and DNS exercises over five years. Our case was braced at Risser 0. The skeletal immaturity and thus the high spinal flexibility and the 17° vertebral rotation may enable better curve correction. The outcome concurs with the report by Aulisa *et al.* (2019), who showed that apical vertebral rotation <20° is associated with better outcomes and that those with Risser 0-2 responded more significantly than those with Risser >2 [5]. The results were in sharp contrast to the report by Zhu *et al.* (2017) and Razeghinezhad *et al.* (2021), who showed less improvement in cases with Risser 0-2, as opposed to patients with Risser >2 [12,13].

Other factors that contribute to the good outcome of the present case may include the high in-brace correction and the very good compliance of the patients with bracing and PSSE. The in-brace correction was 60.2%. Katz *et al.* (2001) reported that an in-brace correction of more than 25% for a double curve is associated with an increased possibility for success [14].

We speculated that the marked differences in the outcome of the different studies related to the Cobb angles might be associated with the type of braces used [4] and possibly the expertise and skills of the orthotists [15]. Most of the above studies with the best results are conducted in Italy by

physicians specializing in scoliosis treatment [3,5,11]. They employed the Lyon and the PASB braces, which have been shown to have a high curve correction rate [4].

Also, the expertise and skills of orthotists likely play a role in the success of the above studies [3,5,11]. Danielsen *et al.* (2007) reported that none of their cases with curves less than 40° worsened, and the authors attributed the excellent outcome of the bracing to the very committed orthotist [15].

The case report illustrates that bracing and PSSE may have a place in managing AIS with Cobb angle in the surgical range. The report, however, has some limitations. We report the outcome at the end of treatment, not two years after termination of therapy. There is a possibility that the curves may progress post-treatment. Also, the curve type changed from right thoracic to right thoracolumbar, with the curve apex changed from T10/T11 to T12/L1. The change may increase the possibility of low back pain. Further, there was a mild compensatory cervical curve. The impact of these changes is currently unknown. Long-term follow-up studies are needed to assess the stability of the results. Also, given that this is a single case report, we cannot generalize the treatment outcome to include all AIS patients with Cobb angle ≥45°. However, physicians should be aware that the approach may improve and not just stabilize large scoliosis curves. Patients who refuse surgery should be given the possibility of bracing and PSSE management. Surgery should be considered for patients who are refractory to rigorous brace and PSSE treatments.

Conclusion

The case report is the first in Asia, illustrating that bracing and PSSE can improve aesthetics and Cobb angle in a ten-year-old girl with a thoracic curve in the surgical range to just below the threshold of curve progression in adulthood. While the outcome cannot be generalized, we believe bracing, and PSSE can be employed in managing patients with curves ≥45°, especially those with a flexible curve and a Risser sign between 0-2, before considering surgery. Indeed, curves refractory to the treatment should be referred for surgery, which aligns with the SRS guidelines.

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