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Case Study

Reduction of Scheuermann's deformity and scoliosis using ScoliBrace and a scoliosis specific rehabilitation program: a case report

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Abstract. [Purpose] There is a paucity of high-quality data pertaining to the conservative management of adult spinal deformity, particularly Scheuermann's kyphosis. Long-term follow-up data for both treated and untreated Scheuermann's patients is also lacking. Given that changes in sagittal balance are associated with increased morbidity, and that these changes are increasingly prevalent in the spines of ageing populations, it is imperative that potential strategies aimed at reversing or minimizing this type of deformity are explored. As the number of elderly patients in developed countries increases, so does the need for a safe and effective non-surgical management option for patients with spinal deformity/sagittal imbalance. This case study details the influence of ScoliBrace rigid TSLO bracing in combination with a specific rehabilitation program in an adult patient with Kypho-scoliosis. [Participant and Methods] The authors describe a case involving the treatment of a 26-year-old male with Scheuermann's kyphosis and a lumbar scoliosis. The patient received 12 months of bracing with a supplemental exercise program. The patient was followed for a period of approximately 12 months. Patient progress was assessed using ODI, SRS-22r, NPRS, and radiographic Cobb angle measurements throughout treatment. [Results] The patient presented with an initial ODI score of 18/100, a SRS-22r score of 3.0, and an average NPRS score of 4/10. Initial Cobb angle measurements demonstrated a 79° thoracic kyphosis and a 30° (coronal plane) lumbar scoliosis. At the final assessment, the patient reported an ODI score of 6/100, an SRS-22r score of 3.91, and an average NPRS score of 0/10. The coronal plane Cobb angle measured 63°, and the thoracolumbar scoliosis had reduced to 25°. [Conclusion] The findings from this case study highlight that this type of brace in combination with exercise rehabilitation may be useful for reducing the magnitude of curves and reducing symptoms in patients presenting with adult kypho-scoliosis. Further investigation of this style of treatment is warranted in patients with sagittal plane imbalance.

Key words: Scoliosis, Kyphosis, Braces

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INTRODUCTION

Adult scoliosis is defined as a spinal curve with a Cobb angle measuring greater than 10° in the coronal/frontal plane in a skeletally mature individual. This form of scoliosis is classified based primarily on the mechanism of onset: type I: primary (*de novo*) degenerative scoliosis; type II: progressive adolescent idiopathic scoliosis (AIS) in an adult patient; or type III: a) secondary degenerative scoliosis in response to primary deformity/anomaly located in the spine, trunk or extremities or

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b) any systemic condition that may affect bone mineral density or metabolism e.g. osteoporosis[1]. Based on figures from the United States[2] adult scoliosis has a prevalence of 8.3%, and is more common in females. The symptom pattern in adult scoliosis can be quite varied, however, most patients present with back pain, leg pain and claudication, with overt neurological findings absent in the majority of cases[1].

Scheuermann's kyphosis, was first described in 1920[3] as a rigid kyphosis associated with vertebral body wedging that was observed in late childhood. Incidence rates as high as 7.4% in the population have been reported[4]. Although the diagnostic criteria for this condition is a topic of debate in the literature, the diagnosis of Scheuermann's kyphosis is usually considered when the sagittal plane Cobb angle is ≥45° with associated disc space narrowing, vertebral body wedging, endplate irregularities and/or Schmorl's nodes[5]. The condition is often painful in the acute stages[6] and can contribute to marked sagittal plane deformity that progresses into adulthood. Postural perturbations common to this condition include an angular thoracic kyphosis, often with accompanying compensatory lumbar hyper-lordosis and increased cervical lordosis. On examination, the head is commonly protruded forward and the shoulders anteriorly positioned[6].

With respect to treatment for Scheuermann's kyphosis and scoliosis, a course of conservative therapy is recommended, with surgical intervention reserved for those patients with severe pain and/or disability at the time of the initial consultation or for individuals who have not responded to conservative management attempts. We present a case involving the reduction of a scoliosis, Scheuermann's kyphosis and associated postural deformity using a ScoliBrace and a scoliosis specific rehabilitation program in a 26-year-old male.

PARTICIPANT AND METHODS

On the 22nd of February 2016, a 26-year-old Caucasian male presented to the lead author's chiropractic clinic suffering from lower back pain, poor posture, and a previous diagnosis of Scheuermann's kyphosis and AIS. The patient reported difficulty with prolonged standing and sitting, dissatisfaction with his cosmetic appearance, and difficulty with leisure activities such as rock climbing. With reference to previous interventions, the patient was diagnosed with Scheuermann's kyphosis and scoliosis at age 13. The patient's doctor had observed the curve up until the patient was aged 15 years. After this point, the patient was referred to the local Children's Hospital and was prescribed a hospital made thoraco-lumbo-sacral orthosis (TLSO) which he wore full-time (23 hours per day) between the ages of 15–17 years. The patient stated that the brace had been designed to hold his curves in place to avoid progression of the scoliosis, but had not addressed his kyphosis. The patient had also received several epidural injections for lower back pain in his early twenties, but stated that he did not wish to continue this style of intervention long-term. The patient's main complaint was continued dissatisfaction with his physical appearance.

A standard history and physical examination was performed by the lead author, a chiropractor with eight years of clinical experience. The patient rated his back pain at the time of presentation, on a numeric pain rating scale (NPRS), as 4/10 on average and 7/10 at worst. The patient's medical and family history were unremarkable. On examination, the patient reported a score of 18/100 on the Oswestry Disability Index questionnaire (ODI), and a 3.0 on the Scoliosis Research Society questionnaire (SRS-22r). The patient's lowest score (2.6) on the SRS-22r subscales was in the *self-image/appearance* domain.

Full spine radiographic assessment was performed which revealed a thoracic hyper-kyphosis measuring 79° Cobb (Fig. 1), and a 30° Cobb lumbar scoliosis and sacral obliquity (Fig. 2). A loss of disc height, vertebral wedging and endplate irregularities were noted at several levels in the mid-thoracic spine. A true leg-length discrepancy (short left leg relative to the right) of 6 mm was also noted during the radiographic examination. The patient was diagnosed with type II adult scoliosis and Scheuermann's kyphosis and was prescribed a ScoliBrace custom spinal orthosis, a rehabilitation program and a 6 mm heel lift.

On the 5th of April 2016, the patient was fitted with a ScoliBrace, which is a customized, lightweight, rigid, thoraco-lumbo-sacral orthosis (TSLO) made from polypropylene copolymer and the 6 mm heel lift (Fig. 3).

In this particular brace, the primary goal was to achieve improvement in the thoracic kyphosis and the sagittal balance while also addressing the lumbar scoliosis and coronal imbalance. In general, this orthosis is designed to place the patient in an in-brace position that attempts to correct the spine and posture in three dimensions. In the coronal plane, the goal is to achieve a "Mirror Image" of the spine and posture. The concept of using a Mirror Image to reverse posture in spinal rehabilitation was first described by Harrison et al[7]. In the transverse plane, when treating the lumbar or thoracolumbar spine, internal lateral bending forces are used to the induce coupled spinal motions of rotation to de-rotate the spine.

The patient had been told that his previous TLSO (Boston brace) had been designed to prevent the progression of his scoliosis. Boston type braces typically involve a symmetrical module with pads placed inside the brace to achieve correction/stabilisation of a scoliosis using 3-point pressure[8]. In contrast to the previous TLSO, the ScoliBrace is designed with a custom asymmetrical module which places the patient into a corrected position. The asymmetrical position of the body in the ScoliBrace straightens the spine via spinal coupling. In a Boston type TLSO the internal pads create corrective forces using 3-point pressure.

With regards to sagittal alignment, the patient had expressed that there had been no noticeable change to this aspect of his spinal deformity in the old brace. In the sagittal plane, the new brace was designed to normalize the sagittal alignment and balance. The new brace featured a strong posteroanterior and inferior-superior push in the mid-thoracic spine to extend and

Fig. 1. Patient's initial lateral postural assessment (Left) and lateral spine radiograph (Right).

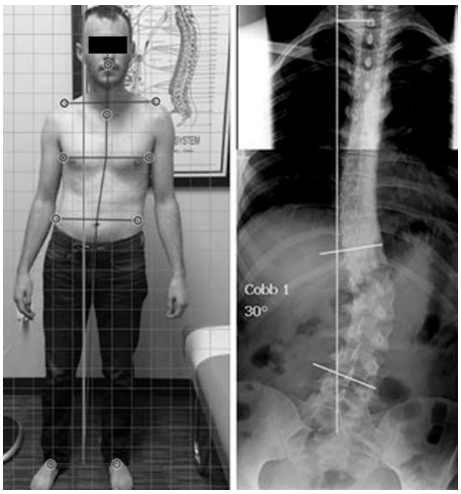

Fig. 2. Patient's initial AP postural assessment (Left) and AP spine radiograph (Right).

Fig. 3. AP view (Fig. 3A) and Lateral view (Fig. 3B) with patient wearing spinal orthosis with 6 mm heel lift.

flatten the kyphosis as well as improve the sagittal balance. Anterior paddles that extended from the main brace module up to the anterior aspect of the clavicles were used to create an anteroposterior force on the upper trunk to encourage thoracic extension.

The magnitude of corrective forces that may be applied using the ScoliBrace are dependent upon the patient's age, flexibility, curve type and the specific etiological factors responsible for the observed deformity. In addition to the brace, the patient was given home stretching and strengthening exercises which reinforce the corrected postural position being modelled by the orthosis. Specifically, the patient was prescribed 'birddog' exercises (alternating extending opposite leg and arm while on all fours [quadruped position]) while wearing the brace.

The stretching component of the rehabilitation program incorporates the ScoliRoll, which is a foam device designed to mobilize scoliotic curves via a traction-fulcrum mechanism (Fig. 4). In a side-lying position, the patient places the ScoliRoll at the apex of the convexity of the curve and maintains this position for up to 20 minutes. The ScoliRoll is designed to mobilise the spine and paraspinal structures using the patient's body weight and respiratory movements. Specific exercises

Fig. 4. Patient side-lying on the ScoliRoll positioned at the apex of the convexity of the thoracolumbar curve.

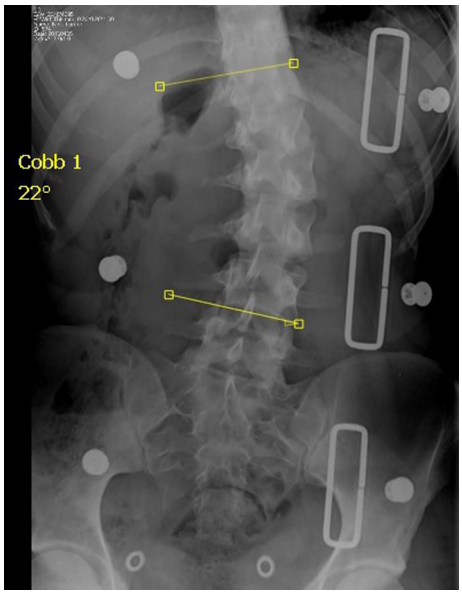

Fig. 5. In-brace AP radiograph.

may also be performed while the patient lies on the foam device. In this case, the patient laid on his left side with the ScoliRoll placed at the apex of the lumbar curve for up to 20 minutes. The patient was instructed to perform repetitions of arm and leg abduction whilst laying on the ScoliRoll.

The treatments, both bracing and rehabilitation, are applied in a graduated fashion. For example, patients wear the orthosis and make use of the ScoliRoll for small amounts of time in the initial phase of treatment. As comfort and tolerance to these inputs improves the patient will spend more time in the orthosis and work their way up to 20 minutes on the ScoliRoll. Exercises are titrated in a similar fashion as patients make gains in strength and endurance.

In this case, the patient wore the ScoliBrace for 2 hours the first day, and increased the wearing by two more hours each day until he was wearing the brace for 12–14 hours per day. The patient was instructed by treating practitioner to perform the home strengthening exercises whilst wearing the brace. The participant of this case study has given their consent for their case details to be published.

RESULTS

An AP radiograph taken at the time of the brace fitting, revealed that the patient's thoracolumbar curve was reduced in-brace to 22° (Fig. 5). It is important to note that the patient was not wearing their prescribed heel lift for the in-brace x-ray in Fig. 5. There was no in-brace lateral radiograph taken at this time.

A follow-up assessment was performed on the 22nd of August 2016, 4.5-months after the initial assessment. The patient reported that, on average, he had been pain free but had experienced 2/10 pain on occasion. The patient's ODI reduced to 4/100, and his SRS-22r score improved to 3.8. The hyper-kyphosis reduced by 16°, from 79° down to 63°, and the lumbar scoliosis curve was reduced by 5°, from 30° down to 25°.

On 27th of April 2017, 12.5-months after the initial consultation, the patient scored a 6/100 on the ODI and a 3.91 on the SRS-22r. An analysis of follow-up radiographic images (Fig. 6) showed a maintenance of the original postural improvements (Table 1). The patient was compliant with the bracing and stated that he wore the brace daily for the recommended time. The patient was not as compliant with the rehabilitation protocol. He reported using the ScoliRoll once per week and occasionally doing the strengthening exercises. He did not report any adverse events during the treatment or follow-up period.

DISCUSSION

The authors have presented a case involving the reduction of a scoliosis and Scheuermann's kyphosis using a ScoliBrace and a rehabilitation program in an adult patient. The patient's age and symptom pattern are consistent with type II adult scoliosis as classified by Aebi[1)] and a typical Scheuermann's presentation[9)]. The presence of scoliosis and hyper-kyphosis in this case is not uncommon, with a substantial proportion of Scheuermann's patients presenting with comorbid scoliosis[10, 11)]. The management algorithm in patients presenting with adult scoliosis typically consists of a trial of conservative care, with more invasive interventions reserved for non-responders[12)]. In certain patients, conservative management may be bypassed

Fig. 6. Patient's final (12.5-month follow-up) AP (Left) and lateral radiograph (Right).

Table 1. Baseline and Follow-up Outcomes

Outcome	Initial	Follow-up 1	Follow-up 2
ODI	18/100	4/100	6/100
SRS-22r	3.0	3.77	3.91
NPRS (Average)	4/10	0/10	0/10
NPRS (Worst)	7/10	2/10	2/10
Lateral Radiograph	79°	63°	63°
AP Radiograph	30°	25°	25°

AP: Anteroposterior; NPRS: Numeric Pain Rating Scale (0–10); ODI: Oswestry Disability Index (0–100); SRS-22r: Scoliosis Research Society 22-item questionnaire.

due to the severity of symptoms on initial presentation e.g. neurological symptoms, or the presence of other non-modifiable patient-specific clinical factors. Progressive AIS curves between 30–50° warrant appraisal by a surgeon due to a high risk of progression in this group[13]. Sagittal plane hyper-kyphotic curves also demonstrate a propensity for progression[14]. The patient in this case would therefore have been considered a candidate for surgery at the time of the initial consultation based on his Cobb measurements. The symptoms that the patient complained of during the initial examination, although not debilitating, were also affecting his quality of life.

Given the estimated average rate of progression for progressive AIS curves in adults is approximately 0.82° per year[15] treatments that may halt progression and/or alleviate symptoms associated with abnormal spinal curvatures are needed. In the domain of adult scoliosis, the mainstay conservative treatment options for adult scoliosis patients include physical therapy, nerve root of epidural steroid injections and pharmacological therapy[16]. Patients in this group spend considerable amounts of money on conservative treatments[17, 18] however very little high-level research has been conducted on the influence of modern bracing techniques as a corrective and/or therapeutic intervention for adult scoliosis patients. Weiss and Dallmayer[19] described a case involving a 47-year-old female patient with a 55° lumbar scoliosis and a 30° upper lumbar kyphosis. The authors reported a dramatic short-term improvement in claudication symptoms, but not pain, that coincided with the application of a sagittal re-alignment brace. Building upon these findings Weiss[20] conducted a follow-up study, prospectively following a group of 29 chronic low back pain patients managed with the sagittal realignment brace. The authors observed significant reduction in pain levels, however participant compliance with brace wearing was very low (24% [7/29]) which hinders the interpretation of the findings. Papadopoulos[21] conducted a study on bracing and exercise which demonstrated promising results for improving Cobb angles, pain and cosmesis. This study however was also plagued by poor participant compliance and dropout. Weiss et al.[22] presented another case report detailing the reduction of a large lumbar curve in a 37-year-old female patient via the use of a recompensation brace in combination with scoliosis specific exercises. Most recently, Palazzo et al.[23] demonstrated a statistically significant reduction in the rate of curve progression (from 0.7° ± 0.06°/year to 0.24° ± 0.43°/year) in a small group (n=9) of adults with progressive AIS treated with a custom-molded lumbar-sacral orthosis.

The body of literature regarding the effect of bracing for adult patients with Scheuermann's kyphosis is scant. One of the few pieces of literature on this topic is a case study by Berdishevsky[24] who reported improvement in the sagittal plane curves in a 76-year-old female using a six-month, intensive regimens of bracing and scoliosis specific rehabilitation.

It is likely that the specific design of the brace was responsible for the outcomes observed in this case. Based on the patient's report, it is possible that the previous TLSO had not adequately addressed the patient's sagittal plane misalignment.

There are several limitations to this case study. The relative contribution of each component of the treatment protocol (orthosis, heel lift, ScoliRoll and exercise) to the result obtained is difficult to establish. Certainly, the specific contribution of the prescribed exercise has been lessened by the reported non-compliance. This case reports the preliminary results of a combination of intervention strategies that included bracing. There are anecdotal reports and some research evidence in the

literature on scoliosis to suggest that bracing may have deleterious effects on trunk muscles in the long term. Further medium and long-term follow up will be required to ascertain the impact of bracing on the patient's trunk muscles and also to better understand if the treatment effects can be maintained. It is also important to note the patient was a young adult male with a hyper-kyphosis that was likely a post-Scheuermann's presentation. It is unclear whether the protocols employed in this study would be applicable in other clinical scenarios, e.g. degenerative kyphosis, or in older patient populations where mobility/flexibility issues, decreases in bone mineral density and sarcopenia prohibit the use of certain management strategies.

There is an absence of high-level studies on the impact of bracing and exercise programs for adult scoliosis and/or Scheuermann's patients. This case therefore represents a novel contribution to the literature regarding the non-surgical management of adult coronal and sagittal plane deformity. Specifically, this case demonstrates that bracing in combination with scoliosis specific exercises may be useful for the reduction of adult scoliosis and Scheuermann's kyphosis and improve pain and self-image in patients with these conditions. No adverse events were reported and the compliance and tolerance to the bracing protocol and exercise regimens was acceptable. The findings of this case would suggest that further investigation into this type of therapy using more robust research designs and longer follow-up periods appear warranted in this patient population.

Funding

There was no source of funding for this case study.

Conflict of interest

JM is the owner and director of ScoliCare a company that provides treatment and educational products for practitioners, and patients with scoliosis. JM is the creator of the ScoliBrace orthosis and the ScoliRoll rehabilitation tool. BTB is a paid employee of Scolicare. There are no other conflicts of interest declared.

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All authors were involved with the conception of the manuscript. Both JM and BTB were involved with the drafting and write up of the manuscript. All authors were involved in the review of the manuscript.

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