Volume: 23, Issue: 4, October 2012 pp.: 283-293 

turkishspine

# VERTICAL EXPANDABLE PROSTHETIC TITANIUM RIB (VEPTR) TECHNIQUE FOR THE TREATMENT OF EARLY ONSET SCOLIOSIS: THE EFFECT ON GROWTH AND THE CORRECTION OF SPINE DEFORMITY, SAGITTAL AND CORONAL BALANCE, AND SHOULDER BALANCE

*ERKEN BAŞLANGIÇLI SKOLYOZLARIN TEDAVİSİ İÇİN VERTİKAL EKSPANDABL PROSTETİK TİTANYUM RİB (VEPTR) TEKNİĞİ. OMURGA DEFORMİTESİNİN DÜZELTİLMESİNE VE BÜYÜMESİNE ETKİSİ, SAGİTAL VE KORONAL DENGEYE ETKİSİ, OMUZ DENGESİNE ETKİSİ*

Yunus ATICI[1],
Akif ALBAYRAK[1],
Mehmet Temel TACAL[1],
Sami SÖKÜCÜ[2],
Kubilay BENG[3],
Seçkin SARI[1],
Mehmet Akif KAYGUSUZ[4]

*[1]Surgeon, S.B. Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Orthopedics and Traumatology Clinics, Spinal Diseases Surgery and Prosthesis Surgery Group, İstanbul.*
*[2]Surgeon, S.B. Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Orthopedics and Traumatology Clinics, Trauma and Deformation Group, İstanbul.*
*[3]Surgeon, S.B. Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Orthopedics and Traumatology Clinics, Pediatric Orthopedics Group, İstanbul.*
*[4]Assoc. Prof. Dr., Training Responsible, S.B. Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Orthopedics and Traumatology Clinics, Spinal Diseases Surgery and Prosthesis Surgery Group, İstanbul.*

**Address:** Dr. Yunus Atıcı, S.B. Metin Sabancı Baltalimanı Kemik Hastalıkları Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, Omurga Hastalıkları Cerrahisi ve Protez Cerrahisi Grubu, Baltalimanı, Sarıyer / İSTANBUL
**Tel.:** 0505 4921945
**E-mail:** yunatici@hotmail.com
**Received:** 1st August, 2012
**Accepted:** 21th September, 2012

## SUMMARY:

**Objectives:** The purpose of this study is to evaluate the effects of VEPTR on spine growth and deformity improvement, and the complication rates.

**Materials and Methods:** In our institute between 2009 and 2011, 12 patients were instrumented with VEPTR without fusion for the treatment of progressive early onset scoliosis. Diagnoses included six patients with congenital scoliosis (five patients had fused ribs), two cases of infantile idiopathic scoliosis, two cases of syndromic scoliosis, one case of neuromuscular scoliosis, and one case of juvenile idiopathic scoliosis. The mean age at the time of surgery was 4.1 (range: 1.6–9) years. The mean duration of follow-up was 1.5 (range: 1–2.5) years. The average number of lengthenings was 3.6 (range: 2–5) per patient. The average interval between lengthenings was 6.9 (range: 5.5–9.5) months. Radiographic evaluation included the measurement of changes of the deformity Cobb angle, the T1–S1 distance, the coronal, sagittal and shoulder balance, and the kyphosis.

**Results:** The mean preoperative scoliosis improved from 66° (range: 48–88°) to 52° (range: 32–85°) postoperatively, and was 63° (range: 40–96°) at the last follow-up. The mean total T1–S1 elongation was increased by 1.8 cm per year. Nine of the 12 patients (75%) had 21 complications (1.75 complications per patient) during the treatment period (five distal hook dislodgements, five rib cradle cephalad migrations, five deep wound infections, two rib cradle caudal migrations, two distal screw pull-outs, one crankshaft phenomenon, and one superficial wound infection).

**Conclusion:** Spinal deformity (scoliosis and shoulder, coronal and sagittal balance) was not effectively controlled by the VEPTR system in this study. Although this system allows for the continued growth of the spine, it has high complication rates.

**Keys words:** VEPTR, early onset scoliosis, correction, balance.

**Level of Evidence:** Retrospective clinical study, Level III

## ÖZET:

**Amaç:** Bu çalışmada ki amacımız, erken başlangıçlı skolyozlu hastalarımıza uyguladığımız VEPTR tekniğinin etkisini ve güvenirliğini geriye dönük olarak değerlendirmektir.

Gereç ve Yöntemler: Çeşitli etiyolojiye sahip erken başlangıç skolyozlu 12 hasta (konjenital skolyozlu 6 hasta, sendromik skolyozlu 2 hasta, infantil idiopatik skolyozlu 2 hasta, nöromüsküler skolyozlu 1 hasta, jüvenil skolyozlu 1 hasta) VEPTR tekniği ile ameliyat edildi. Hastaların ameliyata başlama ortalama yaşı 4.1 (aralık, 1.6-9) idi. Ortalama takip süresi 1.5 yıl (aralık, 1- 2.5) idi. Ortalama distraksiyon sayısı 3.6 (aralık, 2-5) idi. Ortalama uzatma süresi 6.9 ay (aralık, 5.5-9.5) idi. Radyografilerinde ana eğriliğin Cobb açısı, T1-S1 uzunluğu, korreksiyon miktarı, koronal dengesi, sagittal dengesi, omuz dengesi ve kifoz açısı değerleri ölçüldü.

**Sonuçlar:** Ameliyat öncesi Cobb açısı ortalama 66˚ (aralık, 48˚-88˚), ameliyat sonrası 52˚ (aralık, 32˚-85˚), ileri takip döneminde 63˚ (aralık, 40˚-96˚) olarak ölçüldü. T1-S1 mesafesinde ortalama 1.8 cm/yıl uzama elde edildiği belirlendi. 12 hastanın 9'unda (% 75), 21 komplikasyon meydana geldi (5 kez kaudal çengel dislokasyonu, 5 kez kosta kavrayıcının başa doğru migrasyonu, 5 kez derin yara enfeksiyonu, 2 kez kosta kavrayıcının kaudale doğru migrasyonu, 2 kez distal vida dislokasyonu, 1 kez kranşaft fenomeni, 1 kez yüzeyel yara enfeksiyonu).

**Çıkarımlar:** VEPTR'ın erken başlangıçlı skolyozun tedavisinde erken takip döneminde omurganın büyümesine izin verirken, yüksek oranda komplikasyonlara yol açtığını, sagittal ve koronal denge ile omuz dengesini sağlamada yetersiz olduğunu, eğrilikte yetersiz düzelme sağladığını belirledik.

**Anahtar Kelimeler:** VEPTR, erken başlangıçlı skolyoz, korreksiyon, denge.

**Kanıt Düzeyi:** Retrospektif klinik çalışma, Düzey III

## INTRODUCTION:

The enlargement of the vertebrae, lung and chest wall are dependent on each other. They should be considered together as the costa–vertebra–lung complex and should be approached as an elastic structural model. For the lung and thorax to grow, the vertebral elasticity should be protected[7].

Early onset scoliosis (EOS) might involve different etiologies, such as infantile idiopathic scoliosis, juvenile idiopathic scoliosis, congenital scoliosis, syndromic scoliosis, or neuromuscular scoliosis[1]. Progressive early onset scoliosis blocks lung development by inhibiting the direct pulmonary artery and alveolar growth[12]. Therefore, early period treatment is required, as the curvatures continue severely and progressively and inhibit visceral and respiratory development and normal spinal growth[1].

Treatment of progressive early onset scoliosis with a plaster or brace is not effective (except for some cases of infantile idiopathic scoliosis), and might result in additional complications (skin irritation, pressure wounds, ventilation problems, superior mesenteric artery syndrome, psychological problems, developmental retardation of the chest wall, slipping of the plaster or brace)[1,9].

When spinal fusion is administered at an early age, it prevents the growth of the vertebrae and the development of the lung and thorax[7]. New methods without fusion have been developed to allow continued development of the lung and chest wall and the growth of the vertebrae (such as the VEPTR method, the growing rod method).

The VEPTR system is set from costa to costa for the treatment of chest wall deformation, and from costa to vertebra or between ilium for the treatment of scoliosis[4,6].

VEPTR, with applied extensions, allows the development of the chest wall by a direct effect, by enlarging the shrunken hemithorax, and allows the correction of scoliosis and growth of the vertebrae by an indirect effect[3,5,6]. Since alveolar development continues until the age of 8, placement of VEPTR before the age of 8 is most effective[7,20]. VEPTR was originally designed for the treatment of thoracic insufficiency caused by early onset scoliosis, hypoplastic chest wall deformations and congenital abnormalities with or without costa involvement[4].

Whether the effects of VEPTR provide shoulder balance and coronal and sagittal balance for early onset scoliosis is still being discussed; it has also been reported that VEPTR leads to high complication rates. Therefore, in this study, we aim to analyze the effects of this system on growth, deformation progression and body balance, and the resulting complications.

## MATERIALS AND METHODS:

The VEPTR system was administered to 12 patients with progressive EOS between 2009 and 2011. A decision regarding surgery was taken according to the respiratory insufficiency, age, and the progression of the curvature of the patient. No patient responded to conservative treatment before surgery. The chest and vertebral X-rays, spinal MRI, abdominal ultrasonography, echocardiography and nutritional situations of the patients were evaluated by an orthopedist, a podiatrist, and a chest disease specialist.

Seven of the 12 patients were female and five were male. The preoperative mean age was 4.1 (range: 1.6–9) years. Six of the curvatures were due to an etiology of congenital scoliosis (costa fusion in five), two were infantile idiopathic scoliosis, two were syndromic scoliosis, one was neuromuscular scoliosis and one was juvenile idiopathic scoliosis. All patients were found to have a Risser sign of 0 before surgery. The diagnostic and demographic features of all patients are included in Table-1.

For seven patients, an opening wedge thoracostomy was administered to the rib fusion area on the concave side (congenital scoliosis in six patients, syndromic scoliosis in one patient). The VEPTR system was placed into the concave edge for all patients. A hybrid system alone was set in eight patients, a system from costa to costa alone was set in two patients, and both a hybrid system and a system from costa to costa were set in two patients. For distal fixation, lumbar vertebrae were preferred in eight of the ten patients, and the iliac crest was preferred in two patients.

## RADIOGRAPHIC EVALUATION:

Radiological evaluation of the patients was performed with lateral and anteroposterior orthoroentgenograms, taken before and after surgery and after the advanced follow-up period. The Cobb angle, kyphosis angle, shoulder balance, coronal and sagittal balance, and distance between T1–S1 of the major curvature were measured once and noted by two specialists, before and after surgery and in the advanced follow-up period.

Measurement of the coronal balance in the posteroanterior radiography was performed by measuring the distance between horizontal lines drawn from the central line prolapsing from the middle part of the C7 vertebra. The measurement of the T1–S1 distance was done by taking the middle point of the superior last plaques of T1 in the coronal plane and the middle point of the superior last plaques of S1 (vertical sacral central line). The coronal balance and the distance between T1–S1 were expressed in centimeters.

The sagittal balance was evaluated by looking at the place where a straight line drawn down from the corpus of the middle of the C7 vertebra passed in relation to the posterosuperior corner of the S1 vertebral body. If the line passed from the anterior corner of the S1 body it was accepted as 0, if it passed from the posterior and S1 corpus it was accepted as negative, and if it passed from the anterior and S1 corpus it was accepted as positive.

**Table-1.** Demographic information of the patients

Table 1.
Demography of Patients

| Patients | Gender | First Op. Age | Risser | TRC | Curvature Type | Diagnosis | VETPR (After Surgery) | VETPR (Advanced Follow Up) | Treatment Period/Year | Extention Number | Mean Extention Time range(month) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | f | 5,6 | 0 | Open | T | Congenital | Only(hybrid) | Only(hybrid | 2,5 | 5 | 7,5 |
| 2 | f | 1,6 | 0 | Open | TL | Congenital | Only(hybrid) | Both-mc carty rod | 1,3 | 3 | 7,3 |
| 3 | f | 3,8 | 0 | Open | T | Congenital | Only(hybrid) | Both | 2,3 | 5 | 6,6 |
| 4 | f | 3,6 | 0 | Open | TL | Syndromic | Only(hybrid-mc carty rod) | Both | 1,8 | 4 | 5,7 |
| 5 | f | 3,5 | 0 | Open | TL | Congenital | Both | Only | 1 | 2 | 5,5 |
| 6 | f | 9 | 0 | Open | T | Juvenile IS | Only(hybrid) | Only(hybrid) | 2 | 3 | 7,3 |
| 7 | m | 4,1 | 0 | Open | T | Infantile IS | Only(hybrid) | Only(hybrid) | 2,1 | 4 | 8,3 |
| 8 | f | 7 | 0 | Open | T | Congenital | Only(rib-to-rib) | Only(hybrid) | 2,5 | 4 | 6 |
| 9 | m | 5,5 | 0 | Open | TL | Infantile IS | Only(hybrid) | Only(hybrid) | 1,7 | 3 | 9,5 |
| 10 | m | 2,6 | 0 | Open | T | Congenital | Only(rib-to-rib) | Only(rib-to-rib) | 1 | 2 | 8 |
| 11 | m | 2,4 | 0 | Open | T | Syndromic | Both | Both | 1,3 | 4 | 5,7 |
| 12 | m | 8 | 0 | Open | TL | Neuromuscular | Only(hybrid-mc carty rod) | Only(hybrid) | 1,8 | 4 | 5,7 |

T: Thoracic TL: Thoracolumbar TRC: Triradiate cartilage IS: Idiopathic scoliosis

Thoracic kyphosis in a lateral X-ray was performed from the T5 upper last plaques and T12 lower last plaques. The sagittal balance was expressed in centimeters.

Additionally, to evaluate the shoulder balance, the coracoid height difference (CHD), the clavicular tilt angle difference (CTAD) and the clavicle–rib cage intersection difference (CRID) were measured. CHD was expressed in mm by measuring the distance between horizontal lines drawn from the superior of each coracoid process.

The CTAD was measured as the difference between the angle of the line dividing the proximal clavicles from the middle and the horizontal. The CRID was expressed in mm by measuring the distance between horizontal lines drawn from the intersection points of the clavicle and the second costa insertion. A CHD>9 mm, a CTAD>4.5° and a CRID>9 were defined as shoulder imbalance[2].

Any complications were noted.

## SURGICAL TECHNIQUE:

According to the criteria determined by Campbell, the VEPTR system was applied to the patients. All the patients received surgery under general anesthesia. The patients were laid on the operating table in a lateral decubitus position with the concave edge pointing upwards.

Somatosensorial spinal cord monitorization was not administered during surgery. First generation cephalosporin was administered during the operation as a prophylaxis. When placement of the implant to the upper lumbar vertebra or ileum was required together with modified thoracotomy, a second paraspinal incision was used.

A skin incision was drawn parallel to the caudal starting from 1 cm lateral of the middle line of the upper thoracic vertebra cranially. The skin incision was extended in an L-shape by turning to the anterior from 4 cm lower than the scapula tip caudally. Then, the rhomboid and trapezius muscles were divided into two with electrocautery. A space was formed for the VEPTR system to be placed next to the ribs proximally by accessing the interval between the scapula and chest wall with blunt dissection by retracting the scapula to the superior part. VEPTR was placed in the concave part at the level of the posterior axillary line. Costa–costa was formed with costa holders tied to the superior and inferior. Hybrid VEPTR, on the other hand, was formed with one of the choices for the costa holder placed into the superior and the hook, screw or S-rod (Dunn-McCarthy hook) in the distal. The neurovascular bundle of the costa was protected. The missile in the concave edge was administered to the costa with open wedge thoracostomy. The system was completed by making interconnections between the levels prepared cranially and caudally. Then, they were locked by administering expansion to the system. The extensions were provided by accessing the connectors by small incisions every six months. The distance between the extensions was determined according to the progression of the curvature, nutritional status, complication formation, and summer and semester holidays. The extension amount was performed by administering distraction of 0.5–1 cm. In the initial postoperative period, the patients were followed up in the intensive care unit for two days. Thoracolumbar spinal orthosis (TLSO) was not used for any of the patients during the initial postoperative period and extension period[4].

## RESULTS:

The mean follow-up period of our patients was 18 (range: 12–54) months. The mean number of extensions was 3.6 (range: 2–5). The mean extension period was 6.9 (range: 5.5–9.5) months. All patients were exposed to 51 total surgeries, including 33 extension procedures, 12 starting procedures, and six unplanned surgeries due to complications. No final fusion was performed in any of the patients.

The mean Cobb angle of the thoracic scoliosis of our patients before surgery was 66° (range: 48–88°), the mean Cobb angle after surgery was 52° (range: 32–85°) and the mean Cobb angle in the advanced follow-up period was 63° (range: 40–96°). While the main correction in the major thoracic scoliosis in the initial period after surgery was 21.2, the total correction was detected as 4.6% in the last follow-up period.

The mean T1–S1 distance before surgery was 23.8 (range: 17.5–34.9) cm. A mean increase of 1.8 (range: 0.1–5) cm was detected in the initial period after surgery, and an increase of 2.7 (range: 0.3–5.7) cm was detected in the last follow-up period (a mean extension per year of 1.8 cm).

While there was coronal balance in seven patients before surgery, coronal imbalance was detected in five patients. In the advanced follow-up period, it was seen that the coronal imbalance continued in five of the 12 patients. The mean coronal balance was detected to be 2.2 cm in the preoperative period, to be 2.3 cm in the initial postoperative period, and to be 3.4 cm in the final follow-up period.

While there was sagittal balance in five patients before the surgery, it was detected that there was sagittal imbalance in seven patients. In the advanced follow-up period, sagittal imbalance was seen to continue in six of the 12 patients. The mean sagittal balance was detected to be 2.6 cm in the preoperative period, 2.6 cm in the initial postoperative period, and 2.8 cm in the final follow-up period.

The mean main thoracic kyphosis was 37.3° (range: 20–60°) in the preoperative period, 33.2° (range: 20–52°) in the initial postoperative period, and 35.5° (range: 21–68°) in the final follow-up period. While there was a decrease in the main thoracic kyphosis in the initial postoperative period, an increase in kyphosis was observed in the advanced follow-up period.

While the mean CHD was 16.2 mm before the surgery, it was 12.3 mm after the surgery. However, in the advanced follow-up period, it increased to 16 mm.

While the mean CTAD was 11° in the preoperative period, it was 8° in the postoperative period. It was observed that it increased to 13.4° in the advanced follow-up period. While the mean CRID was 11.4 mm in the preoperative period, it was measured as 8.1 mm in the postoperative period.

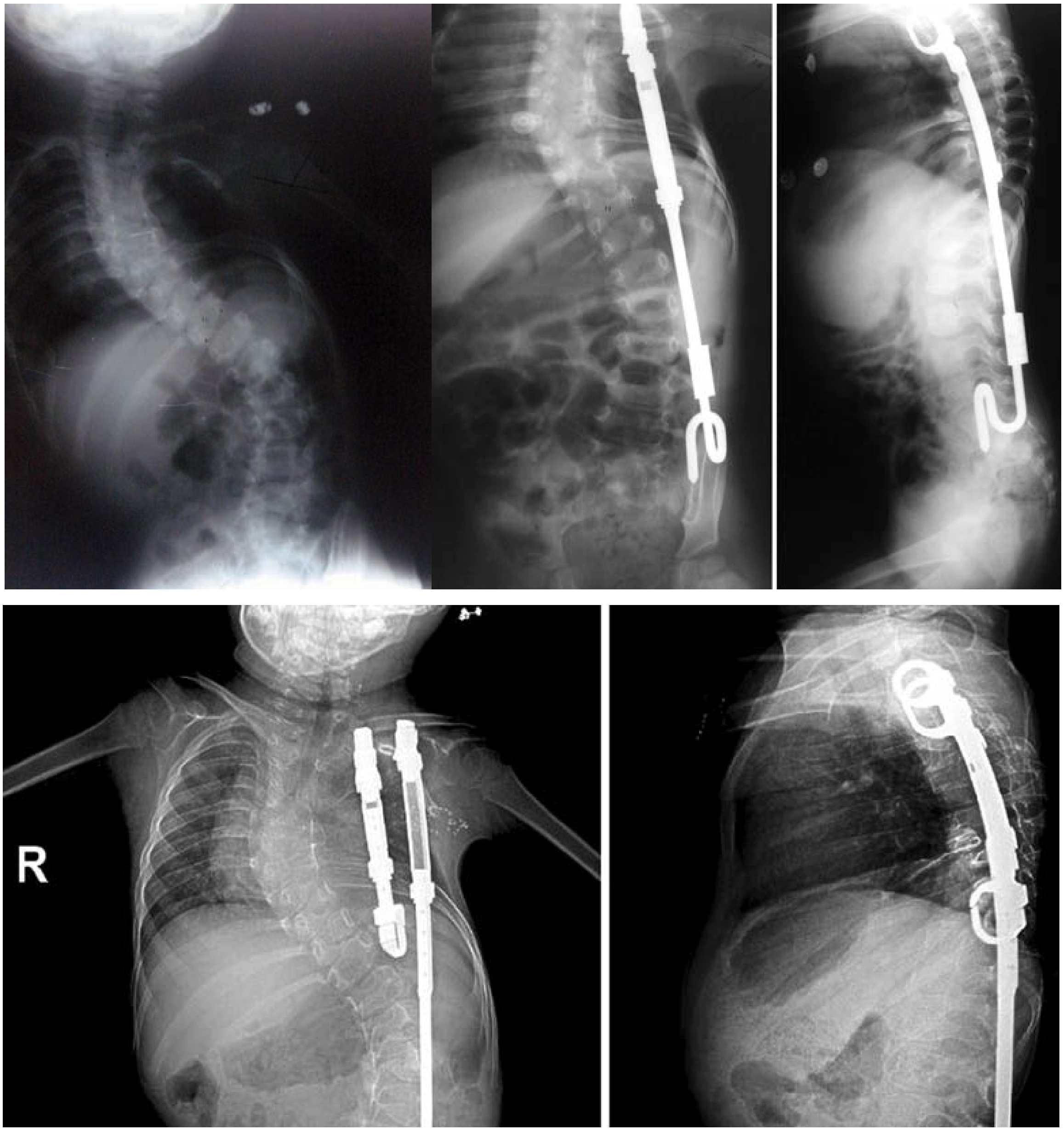

**Figure-1. a.** Anterior-posterior X-ray of the patient before surgery,
**b.** Anterior-posterior and lateral X-rays after surgery,
**c.** and
**d.** anterior-posterior and lateral X-rays in the advanced follow-up period,
**e.** the patient before surgery and
**f.** the same patient after the advanced follow-up period.

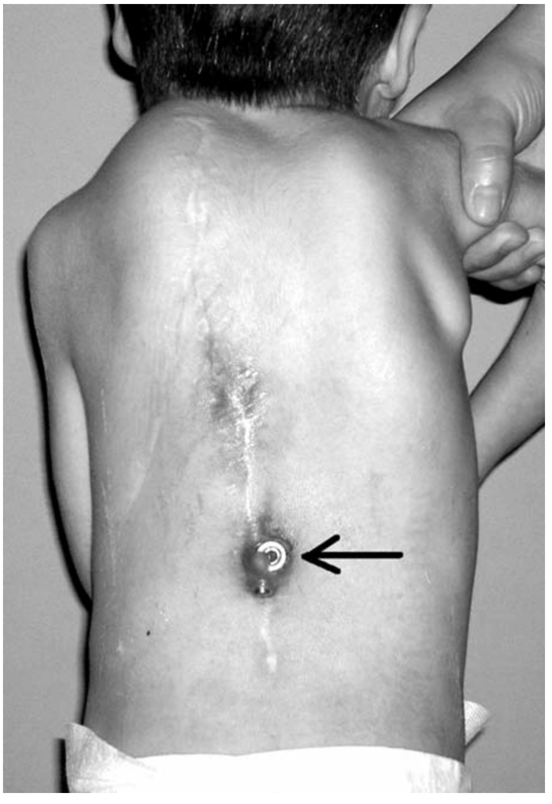

**Figure-2.** Deep wound area infection

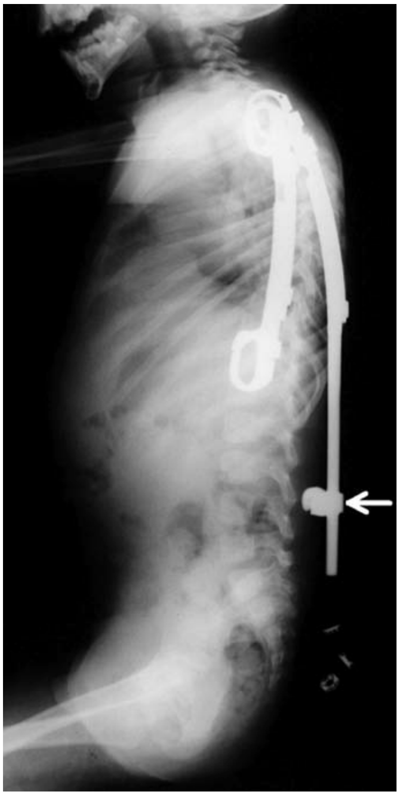

**Figure-3.** Distal hook luxation

However, it was detected to be 12 mm in the advanced follow-up period, and it was seen to worsen.

21 complications formed in nine of our 12 patients (75%) (1.75 complications per patient). These were dislocation of the hook to the caudal five times, migration of the costa holder upwards five times, deep wound infection five times, migration of the costa holder towards the caudal twice, distal screw dislocation twice, crankshaft phenomenon once, and superficial wound infection once. One case ended with exitus due to a deep wound infection. No neurological complications developed in any of the patients. Four patients were exposed to unplanned surgery six times due to complications. Among those complications, there were five debridement surgeries due to deep wound infection and one revision surgery due to implant deficiency. In three patients, due to the curvature and the VEPTR system not controlling the balance, the double growing rod system was changed.

## DISCUSSION:

While considering the use of the VEPTR method for early onset scoliosis, criteria such as etiology, age, the severity of the curvature, the type of the curvature, the existence of a congenital vertebral abnormality, costa fusion and the existence of thoracic deficiency should be considered.

**Effect on the vertebral growth:**

The normal longitudinal growth of the vertebra is provided by the exposure of the last plaques of the vertebra to mechanical loads in a balanced manner.

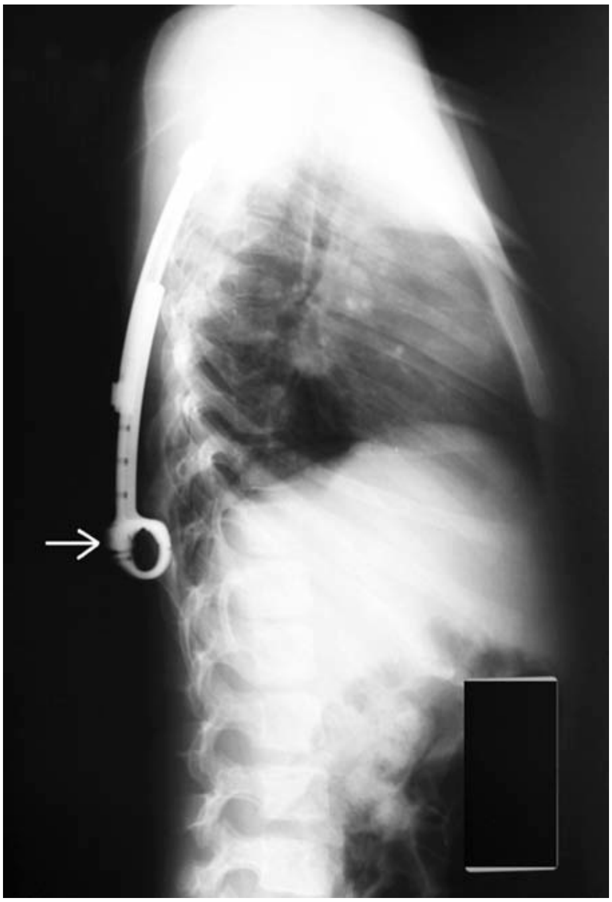

**Figure-4.** Migration of distal costa holder

Abnormal spinal growth is encountered on exposure of the vertebra to asymmetrical loads. According to the Heuter-Volkmann principles, one of the mechanisms by which scoliosis is thought to develop is as a result of the exposure of the vertebrae to asymmetrical loads[11,18]. The balance in spinal growth also depends on the balance of the muscles in the body, the pressure in the thorax, the mechanical push of the costa on the vertebrae, and the growth of the costa[13,14].

Spinal growth reaches a peak in the first five years of life. Two-thirds of the final adult sitting height is completed by five years of age. The mean T1–12 distance at birth is 18 cm. The extension of the distance between T1–S1 from 0–5 years of age is 10 cm, or 2.2 cm/year (the increase in the T1–12 distance is 1.1 cm/year). The increase in distance from T1–S1 from 5–10 years of age is 5 cm in total, or 1.1 cm/year[7,8].

The VEPTR method allows the growth of the vertebrae by an indirect effect[6,10]. Campbell et al. administered expansion thoracostomy with a VEPTR procedure to 21 patients with congenital scoliosis and costa fusion. They reported approximately 0.8 cm/year total growth in the thoracic area of patients with an average age at operation of 3.3 years and follow-up period of 4.2 years[3]. In another study, Campbell published the results of 27 patients with congenital scoliosis and 5.7 years of follow-up, who received a VEPTR procedure and open wedge thoracostomy. The increase in the distance between T1–12 was detected as an average of 0.71 cm/year[6]. Emans et al. published the results of 31 patients who received the VEPTR procedure due to congenital vertebral abnormalities and costa fusion. They detected the thoracic vertebral growth as 1.2 cm/year in patients with an average of 2.6 years of follow-up[10]. In our study, on the other hand, we detected the extension of the distance from T1–S1 as 1.8 cm/year. When the three studies above and our study are compared with Dimeglio's normal spinal growth rates, we can see that the VEPTR system allows a growth rate similar to the normal growth rate of the spine.

### The Effect on the Thoracic Vertebral Correction:

According to a study by Campbell et al. in 2004, they showed a deformation before surgery of 74°, a mean Cobb angle of 56° after surgery, and a mean Cobb angle of 49° in the advanced follow-up period (a mean total correction of 33.8%)[6].

In a study by Samy et al., it was reported that the mean Cobb angle of the thoracic scoliosis before surgery was 49.8°, after surgery it was 35.6°, and it was 30.2° in the advanced follow-up period (a mean total correction of 39.4%)[15]. According to a study by Emans, while the mean Cobb angle of patients with scoliosis was 55° before the operation, it was 39° after the operation and 43° in the advanced follow-up period (a mean total correction of 21.8%)[10]. The mean correction of the deformation after the last follow-up period was reported to be 35.1% in a study by Schulz[17].

In our study, on the other hand, the mean main thoracic correction was detected as 21.2%. One of the reasons why the correction in our study is lower than in the studies mentioned above may be due to the fact that our follow-up period was short. The VEPTR system and expansion thoracostomy were unsuccessful in three of our patients. In three patients, the VEPTR system was removed and a double growing rod system was placed instead. In this case study, we detected that the VEPTR system could not provide sufficient control of the spinal deformation.

### The Effect on Sagittal and Coronal Balance:

Schulz et al. found that the sagittal and coronal balance was protected in the period before fusion in eight patients with infantile idiopathic scoliosis after a follow-up period of an average of 32 months after VEPTR procedure administration[17]. In our study, there was coronal imbalance in five patients and sagittal imbalance in seven patients before the operation. In the late follow-up period, coronal imbalance was seen in seven of the 12 patients, and sagittal imbalance was seen in six of them.

### The Effect on Shoulder Balance:

Samy et al. operated on 15 patients with congential scoliosis using the VEPTR system. They indicated that they obtained a significant improvement in the CHD and CTAD parameters, meaning that VEPTR resulted in a recovery in the shoulder balance after a mean follow-up period of 28.9 months[15]. However, in our study, the CHD, CRID and CTAD parameters of the patients were evaluated in the preoperative, postoperative and advanced follow-up periods. While, in preoperative radiography, >9 mm CHD and CRID were detected in eight of the 12 patients, both parameters were detected as >9mm in five of the 12 patients in the advanced follow-up period. While CTAD was >4.5° in nine of the 12 patients, it was detected as >4.5° in seven of the 12 patients in the advanced follow-up period. No apparent recovery was detected in the parameters of our patients with regard to the shoulder balance after this short-term follow-up period.

### Complications:

Sankar et al. reported the complication rates of the various types of spinal implants allowing growth and showed that complications occurred in 19 of 45 patients (2.37 complications per patient)[16]. Campbell et al. reported that they encountered 19 complications in 16 patients with early onset scoliosis who received the VEPTR system (1.19 complications per patient)[19]. In another study by Campbell et al., they indicated that they encountered 52 complications in 22 patients with congenital scoliosis that received a VEPTR system (2.36 complications per patient)[6]. In a study by Schulz, they stated that complications were not common in patients with infantile idiopathic scoliosis that received VEPTR[17]. In our study, complications were observed at similar rates to the literature (1.75 complications per patient)[6,16,19].

In our study, a deep soft tissue infection developed in five patients and a superficial wound infection in one patient. All of those patients were exposed to multiple surgical procedures, and insufficient soft tissue closure was seen in all of those patients.

## CONCLUSION:

According to our study, the VEPTR system cannot control spinal deformation effectively. While the VEPTR system allows the growth of the vertebrae, it leads to high rates of complications. Moreover, the VEPTR system cannot recover the shoulder balance efficiently.

## REFERENCES:


1. Akbarnia BA, Marks DS, Boachie-Adjei O, Thompson AG, Asher MA. Dual growing rod technique for the treatment of progressive early-onset scoliosis: a multicenter study. *Spine* 2005; 30(17 Suppl): S46-57.
2. Akel I, Pekmezci M, Hayran M, Genc Y, Kocak O, Derman O, Erdoğan I, Yazici M. Evaluation of shoulder balance in the normal adolescent population and its correlation with radiological parameters. *Eur Spine J* 2008; 17(3): 348–354.
3. Campbell RM Jr, Hell-Vocke AK. Growth of the thoracic spine in congenital scoliosis after expansion thoracoplasty. *J Bone Joint Surg* 2003; 85-A(3): 409-420.
4. Campbell RM Jr, Smith MD, Hell-Vocke AK. Expansion thoracoplasty: The surgical technique of opening-wedge thoracostomy. Surgical technique. *J Bone Joint Surg* 2004; 86- A: 51–64.
5. Campbell RM Jr, Smith MD, Mayes TC, Mangos JA, Willey-Courand DB, Kose N, Pinero RF, Alder ME, Duong HL, Surber JL. The characteristics of thoracic insufficiency syndrome associated with fused ribs and congenital scoliosis. *J Bone Joint Surg* 2003; 85-A: 399-408.
6. Campbell RM Jr, Smith MD, Mayes TC, Mangos JA, Willey-Courand DB, Kose N, Pinero RF, Alder ME, Duong HL, SurberJL. The effect of opening wedge thoracostomy on thoracic insufficiency syndrome associated with fused ribs and congenital scoliosis. *J Bone Joint Surg* 2004;86-A: 1659–1674.
7. Dimeglio A. *Growth of the Spine and Thorax and Effect of Early Fusion* (New Information). 3rd International Congress on Early Onset Scoliosis and Growing Spine (ICEOS) on November 20-21, 2009 in Istanbul, Turkey.
8. Dimeglio A. Growth of the spine before age 5 years. *J Pediatr Orthop Part B* 1993; 1: 102-107.
9. Elsebaie H. *Complications of nonoperative management*. 3rd International Congress on Early Onset Scoliosis and Growing Spine (ICEOS) on November 20-21, 2009 in Istanbul, Turkey.
10. Emans JB, Caubet JF, Ordonez CL, Lee EY, Ciarlo M. The treatment of spine and chest wall deformities with fused ribs by expansion thoracostomy and insertion of vertical expandable prosthetic titanium rib: Growth of thoracic spine and improvement of lung volumes. *Spine* 2005; 30(17 Suppl): S58-68.
11. McCall IW, Galvin E, O'Brien JP, Park WM. Alterations in vertebral growth following prolonged plaster immobilisation. *Acta Orthop Scand* 1981; 52: 327-330.
12. Muirhead A, Conner AN. The assessment of lung function in children with scoliosis. *J Bone Joint Surg* 1985; 67-B: 699–702.

13. Piggott H. Posterior rib resection in scoliosis. A preliminary report. *J Bone Joint Surg* 1971; 53-B: 663-671.

14. Roaf R. Vertebral growth and its mechanical control. *J Bone Joint Surg* 1960; 42-B: 40-59.

15. Samy MA, Al Zayed ZS, Shaheen MF. The effect of a vertical expandable prosthetic titanium rib on shoulder balance in patients with congenital scoliosis. *J Child Ortop* 2009; 3: 391-396.

16. Sankar WN, Acevedo DC, Skaggs DL. Comparison of complications among growing spinal implants. *Spine* 2010; 35(23): 2091-2096.

17. Schulz JF, Smith J, Cahill PJ, Fine A, Samdani AF. The role of the vertical expandable titanium rib in the treatment of infantile idiopathic scoliosis:early results from a single institution. *J Pediatr Orthop* 2010; 30(7): 659-663.

18. Stokes IA. Analysis of symmetry of vertebral body loading consequent to lateral spinal curvature. *Spine* 1997; 22: 2495-2503.

19. Thompson GH, Akbarnia BA, Campbell RM Jr. Growing rod techniques in early onset scoliosis. *J Pediatr Orthop* 2007; 27: 354–361.

20. Thurlbeck W. Postnatal human lung growth. *Thorax* 1982; 37: 564–571.