

## THE EFFECT OF A NEW MODIFICATION OF THE GROWING ROD TECHNIQUE ON THE SUCCESS RATE: DISTAL AND PROXIMAL PEDICLE SCREW FIXATION, DUAL ROD APPLICATION AND ROUTINE LENGTHENING AT EVERY 6 MONTHS

### UZAYAN ROD TEKNİĞİNİN YENİ BİR MODİFİKASYONUNUN 6 AYDA BİR RUTİN UZATMANIN BAŞARISI ÜZERİNDEKİ ETKİSİ

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#### SUMMARY:

Early-onset scoliosis includes many etiologies and many types of curves usually requiring surgical treatment in young children. Surgical treatments tailored for deformity control and the preservation of growth in young children include fusionless techniques, the most popular of which is the dual growing rod technique. In this prospective study, 22 early-onset scoliosis patients treated with the traditional dual growing rod technique whose foundation anchors were mostly pedicle screws have been followed for a minimum of twenty-four months. Routine lengthenings were performed every six months on an outpatient basis. The radiological progress of the patients was tracked with routine radiographs at each preoperative and postoperative visit. Growth of the vertebral column was evaluated by the measurement of instrumented and uninstrumented vertebral levels. A total of 22 patients whose average age at the index operation was 63.7 months were included in the study; 22 index and 90 routine lengthening procedures were performed. Radiographic progress of the patients was as follows: scoliosis decreased from an average of

50° (range 25°-98°) to 27° (range 8°-52°) post final follow up visit. Kyphosis did not change significantly. Apical vertebral rotation decreased from 20.5° (range 0°-45°) to 14.2° (range 0°-25°) as measured by the Perdriolle method. Segments that were included in the instrumentation increased in height from 16.8 (range 12.5-22) mm to 18.8 (range 12.5-22) mm while segments that were not included increased from 17.6 (range 14.3-23) mm to 19.5 (range 17-22) mm. No final fusions were performed at the time of the study. We have found that distal and proximal pedicle screw fixation, dual rod application and routine lengthenings every six months provide an adequate, safe and effective method for the three-dimensional control of deformity while allowing for continued vertebral growth.

**Key words:** Growing spine, pedicle screw, growing rod technique

**Level of evidence:** Prospective clinical study, Level II

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## ÖZET:

Erken başlangıçlı skolyoz, küçük çocuklarda oluşan ve birçok tanıyı ve eğrilik tipini kapsayan skolyozlara verilen ortak addır. Bu çocuklarda deformitenin kontrolüne yardımcı olan, fakat aynı zamanda büyümeye izin veren tekniklerin arasında füzyonsuz cerrahi bulunur. Bunun da en popüler türü, günümüzde çift uzayan rod tekniğidir. Bu prospektif çalışmada, geleneksel çift uzayan rod tekniği ile tedavi edilen erken başlangıçlı skolyozu olan 22 hasta 24 ay boyunca takip edilmişlerdir. Rutin uzatma operasyonları ayaktan altı ayda bir yapılmıştır. Hastaların radyolojik durumu tüm preoperatif ve postoperatif muayeneleri sırasında rutin düz grafiler ile değerlendirilmiştir. Toplamda ortalama yaşı 63.7 ay olan bu 22 hastaya 22 primer uzayan rod uygulaması ve toplam 90 uzatma ameliyatı yapılmıştır. Hastaların radyolojik gelişimi şöyle olmuştur: skolyotik eğrilikleri preoperatif ortalama 50° (25° ila 98°)'den son uzatma sonrası 27° (8° ila 52°)'ye

düşüş göstermiştir. Kifoz anlamlı olarak değişiklik göstermemiştir. Apikal vertebral rotasyon Perdriolle yöntemiyle ölçülmüş ve 20.5° (0° ila 45°)'den 14.2° (0° ila 25°)'ye düşmüştür. Enstrüman dahilindeki seviyelerin boyu 16.8 (12.5 ila 22) milimetreden 18.8 (12.5 ila 22) milimetreye artış gösterirken enstrüman dışındaki seviyelerin boyu 17.6 (14.3 ila 23) milimetreden 19.5 (17 ila 22) milimetreye artış göstermiştir. Bu çalışmanın sonucunda distal ve proksimal pedikül vidaları kullanılarak yapılan çift uzayan rodlu enstrümantasyon ve bu sisteme yapılan 6 aylık rutin uzatmaların deformitenin üç boyutlu kontrolü için güvenli ve efektif olmakla birlikte omurga büyümesine izin verdiği görülmüştür.

**Anahtar kelimeler:** Büyüyen omurga, pedikül vidası, uzayan rod yöntemi

**Kanıt düzeyi:** Prospektif klinik çalışma, Düzey II

## INTRODUCTION:

The term early-onset scoliosis (EOS) is used to describe scoliosis of many etiologies seen in young children. The treatment of early-onset scoliosis is at best controversial; no clear guidelines exist regarding this issue<sup>(6)</sup>. The initial method of treatment is often conservative, including orthotics and serial castings that more often than not fail to control curve progression. Surgery, when indicated provides many advantages over conservative treatment, yet pitfalls of surgical fusion such as loss of growth have led to the emergence of new techniques, one of which is the growing rod<sup>(6)</sup>.

Many types of growing rod instrumentation have been described including single or dual rod instrumentation, Luque rods referred to as Luque trolleys and though not exactly a rod, the vertical expandable prosthetic titanium rib. As a concept, all of these include different kinds of proximal and distal anchors, referred to as foundations, connected with a rod that is periodically surgically lengthened. Types of implants used in foundations are hooks and pedicle screws, latter of which have been associated with greater pullout strength. Difficulties associated with these techniques include but are not limited to obtaining and maintaining three-dimensional deformity correction, avoiding loss of adequate spinal growth and the reportedly high incidence of complications<sup>(3,6-7)</sup>.

This study prospectively evaluates children at our institution who were treated using the growing rod technique and followed for a minimum of eighteen months. Its purpose is to evaluate the three dimensional control of vertebral deformity using pedicle screws as

proximal and distal foundations and a dual rod construct.

## MATERIALS AND METHODS

Starting from March 2004, 22 patients were instrumented with dual growing rods without fusion. Three patients were excluded from this study because of hooks used as proximal anchors and two other patients were excluded based on the fact that their deformity was purely kyphotic. All remaining patients have pedicle screws as proximal anchors and pedicle screws and/or Galveston instrumentation as distal anchors.

The surgical technique used in these patients is as follows. Exposure is performed through a midline incision until muscular level, which is taken subperiosteally only at the level of proximal and distal foundations. Following confirmation of vertebral level by the image intensifier or intraoperative x-ray, two vertebral levels proximally and distally are exposed subperiosteally and instrumented with four pedicle screws, three pedicle screws and a hook or four pedicle screws and the Galveston method. Limited fusion at foundation sites was achieved by decortication and the use of allograft. Following index surgery, bracing was employed in all patients for the first six months of follow up. Regular lengthening procedures were planned for every six months and the patient discharged after the scheduling of the next surgery. Lengthening procedures were performed on an outpatient basis with the patient reporting for surgery from home and spending the night at the hospital with discharge the following day barring wound complications.

The age, sex and diagnosis of all patients were recorded at the time of every admission. Standing and sitting heights were measured and preoperative standing full spine x-rays were taken. Following surgery, heights were again measured and x-rays repeated. Scoliosis was measured using the Cobb method in preoperative and postoperative x-rays. The degree of apical vertebral rotation was measured in these x-rays using the method of Perdriolle.

## RESULTS

The study went on from 03/2004 to 09/2008. There were a total of 35 patients, 22 girls and 13 boys, whose average age at index operation was 63.7 (range: 27-105 months). Their diagnoses included congenital scoliosis, idiopathic infantile scoliosis, spinal dysraphism, Ehlers-Danlos syndrome, meningomyelocele, neuroblastoma, bone dysplasia and arthrogryposis multiplex congenita. The patients underwent lengthening procedures an average of 3.2 times. Thirteen patients were excluded based on purely kyphotic deformities, proximal hook fixation and limited time of follow up. In the patients who were included 22 index operations and 90 lengthening procedures were performed. Other procedures performed during operations were: multiple eggshell osteotomies (1 patient), single level eggshell osteotomy (1 patient), hemivertebrectomy (1 patient), concave rib osteotomy (3 patients), annulotomy (1 patient). Growing rods were connected end-to-end in 14 patients while they were connected side-to-side in 8 patients. While exposure and instrumentation techniques were the same in all patients,

proximal anchors used were pedicle screws in 29 patients, hooks in 2 patients and both in 4. Distal anchors were pedicle screws in 16 patients, screw and hooks in 1, Galveston instrumentation in 2 and Galveston and screws in 3 patients. Curve progression in patients is as detailed in Table-1.

**Table - 1.** Results of the patients.

	Preoperative index	Postoperative index	%	Final	%	p
Scoliosis	50° (25°-98°)	24° (16°-46°)	52	27° (8°-52°)	46	,000
T2-5 Kyphosis	12° (0°-30°)	14° (0°-30°)		16° (0°-34°)		
T5-12 Kyphosis	31° (0°-88°)	13° (0°-37°)		11° (0°-28°)		
Apical Vertebral Rotation	20.5° (0°-45°)	15° (0°-25°)	29	14.2° (0°-25°)	33	,008

Lengthening procedures were scheduled routinely every six months. No final fusions were performed at the time of the study. Patients' sitting heights increased 26mm per year whereas their standing heights increased an average of 32 mm per year. Segments that were not instrumented increased in height from 17.6 (range 14.3-23) mm to 19.5 (17 to 22) mm. Segments that were included in the instrumentation increased in height from 16.8 (12.5-22) mm to 18.8 (12.5-22) mm. The difference between the increases in height in uninstrumented and instrumented levels was not significant.

During the procedures, no neurological complications were encountered. There were no wound complications. Implant failure leading to loss of correction was not encountered. Rod breakages in two patients

were diagnosed during pre-lengthening visits and exchanged during the lengthening operation, leading to no unscheduled surgery. In three other patients, screw loosening was noted during a lengthening procedure and exchanged accordingly. No unscheduled surgery was performed on the patients.

## DISCUSSION

The treatment of young children with early-onset scoliosis has been challenging. Spinal fusion performed at an early age has the disadvantage of stunting pulmonary growth, while treatment with orthoses has generally been unsuccessful in young children with progressive curves. The growing rod technique has revolutionized treatment of early-onset scoliosis by allowing for growth while providing a reasonable, safe and effective degree of deformity control. The growing rod instrumentation system has been used since the introduction of Harrington rods in the 1960s, although great progress has been made both in hardware and surgical technique. With the advent of dual-rod instrumentation, complication rates have been decreased and deformity control has been improved <sup>(1,4,6)</sup>. Previously reported high complication rates in instrumentation systems using hooks as anchors have been negated by pedicle screw technology. In our study, we have found that using pedicle screws as proximal and distal anchors is a safe and effective technique in three-dimensional deformity control <sup>(1-3,7)</sup>. No increase in the transverse plane deformity was noted during the study. With the appropriate technique and adequate experience, previously reported high complication rates can be lowered.

Pedicle screw use can lower problems related to implant failure. There have been previously published reports of biomechanical comparison of different anchors by Mahar et. al. supporting this finding <sup>(3)</sup>.

Though there have been no reports addressing the appropriate time for lengthenings, this interval has varied among individual institutions between 6 to 18 months <sup>(1-2,6)</sup>. In our institution, we have found that by lengthening every six months, equal growth rates between instrumented and uninstrumented levels can be attained. Lengthening procedures performed as outpatient operations every six months allow the patient to lead a nearly-normal life, and compliance of the families have been very satisfactory. It is of course necessary at the beginning of treatment to inform both the child and the parents of the arduous nature of the treatment for early-onset scoliosis and the benefits of the growing rod technique. Repeated lengthenings may cause more complications while allowing for better growth and deformity control, and their timing must therefore be appropriately considered.

Growth in previous studies has been assessed in the spine as a whole, usually by T1-S1 length measured in AP and lateral plain radiographs <sup>(1-2,6-7)</sup>. This does not prove that instrumented levels have the same rate of growth as uninstrumented levels. Uninstrumented levels may mislead by compensatory overgrowth. There is also the possibility of the distraction of instrumented levels causing overgrowth here. By comparing the change in height of uninstrumented and instrumented levels separately, we have found that there is no significant difference in the

rates of growth between instrumented and uninstrumented levels.

In our study, while there were a number of implant-related complications, all of them could be treated during a routine lengthening procedure and none of them have led to unscheduled surgery. Wound-related complications have decreased with the application of careful suturing techniques. The learning curve for lengthening procedures has also been found to be very favorable, blood loss minimal and surgical times acceptable.

New techniques for less-invasive treatments that require no repeated planned surgeries are being explored. A better implant for the treatment of early-onset scoliosis should allow for growth without the need for scheduled open surgery and be inserted via a less invasive technique. Remote-controlled implants employing computer chips are being researched in many centers. There have been previous reports of animal studies of remote-controlled, motorized growing rods but a fail-safe system for humans is still being developed <sup>(6)</sup>.

## CONCLUSION

Patient with early-onset scoliosis who do not meet the criteria for observation or orthotic treatment still require surgery. While the dual-growing rod technique has proven many times that it is adequate in controlling deformity and has an acceptable rate of complications, it still requires multiple surgeries until the time of final fusion. In the future, newer techniques that do not necessitate open procedures for

lengthening but provide a comparable rate of deformity control should be the focus of research.

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**Figure-1.** 8 year-old girl with Ehlers-Danlos disease and spinal deformity. After 5 lengthenings, deformity is well controlled while she is gaining height.

