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Outcomes of posterior titanium spinal instrumentation in neuromuscular scoliosis patients

Nöromusküler skolyoz hastalarında posteriyor titanyum spinal enstrümentasyonun sonuçları

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Objectives: In this study, we aimed to characterize the outcomes of posterior spinal fusion (PSF) using titanium instrumentation in neuromuscular scoliosis (NMS) patients with a special focus on deformity correction and correction maintenance.

Patients and methods: Between 2002 and 2004, nine patients (5 girls and 4 boys; mean age 14.9±2.3 years; range 11 to 19 years) with NMS who underwent PSF using titanium instrumentation were retrospectively analyzed. The mean height at surgery was 154.6±14.2 cm (range, 136-173 cm) and the mean weight was 59.4±19.2 kg (range, 26-114 kg). The mean follow-up duration was 3.7 years (range, 2-5 years). Preoperative data included demographics, curve type, and surgical indication. Rod size, fusion levels, duration of the operation (min), estimated blood loss (cc), and length of stay in hospital (day) were also evaluated intraoperatively. Postoperative data included correction of deformity, maintenance of correction, and complications. Radiographic measurements were obtained from standing posterior-anterior and lateral spinal radiographs at preoperative, postoperative (at first week after standing; i.e. first erect) and last follow-up visits. The data obtained were analyzed using descriptive statistic methods (mean, standard deviation, median, frequency and percentage).

Results: Dramatic improvements in the spinal deformities were observed in the patients with NMS who underwent PSF using titanium instrumentation. Mean preoperative Cobb angle was reduced from 69.7 degrees to 16.2 degrees at first erect following surgery (at first week; 77% correction). Two-year follow-up revealed that this correction sustained (mean 14.8 degrees). However, moderate to severe postoperative complications requiring careful monitoring were reported.

Conclusion: Our study results showed that PSF with titanium instrumentation in pediatric NMS patients demonstrated satisfactory outcomes during the follow-up period. However, further large-scale studies with a long-term follow-up results are required to generalize the results regarding PSF using titanium instrumentation in these patients.

Key words: Neuromuscular; posterior spinal fusion; scoliosis; titanium.

Amaç: Bu çalışmada nöromusküler skolyoz (NMS) hastalarında titanyum enstrümentasyon ile posteriyor spinal füzyon (PSF) uygulaması sonuçlarının, özellikle deformitenin düzeltilmesi ve düzelmenin korunması açısından ortaya konulması amaçlandı.

Hastalar ve yöntemler: 2002-2004 yılları arasında NMS tanısı ile titanyum enstrümentasyon aracılığıyla PSF yapılan dokuz hasta (5 kız, 4 erkek; ort. yaş 14.9±2.3 yıl; dağılım 11-19 yıl) retrospektif olarak değerlendirildi. Ameliyat tarihinde ortalama boy 154.6±14.2 cm (dağılım, 136-173 cm) ve ortalama ağırlıkları 59.4±19.2 kg (dağılım, 26-114 kg) idi. Ortalama takip süresi 3.7 yıl (dağılım, 2-5 yıl) idi. Ameliyat öncesi sürece ait bilgiler; hastaların demografik özellikleri, eğriliğin tipi ve cerrahi endikasyonunu içermekteydi. Ameliyat sırasında rod kalınlığı, füzyon seviyeleri, ameliyat süresi (dk.), tahmini kan kaybı (cc) ve hastanede kalış süresi değerlendirildi. Ameliyat sonrası döneme ait bilgiler ise hastaların deformitelerinin düzeltilme derecesi, düzelmenin korunması ve komplikasyonları içermekteydi. Radyografik ölçümler ayakta posteriyor-anteriyor ve lateral spinal radyografiler olarak ameliyat öncesi, ameliyat sonrası (ayağa kalktığı ilk hafta; ilk doğrulma) ve son kontrollerinde çekildi. Elde edilen veriler, tanımlayıcı istatistik yöntemler kullanılarak değerlendirildi (ortalama, standart sapma, ortanca, sıklık ve oran).

Bulgular: Titanyum enstrümentasyon ile PSF yapılan NMS hastalarının spinal deformitelerinde belirgin iyileşmeler gözlemlendi. Ortalama Cobb açısı ameliyat öncesi dönemde 69.7 dereceden ameliyat sonrası ilk doğrulma sürecinde 16.2 derece'ye indirgendi (ilk hafta; %77 düzelme). Hastaların iki yıllık takiplerinde mevcut düzelmenin sürdüğü görüldü (ortalama 14.8 derece). Ancak, ameliyat sonrası dönemde dikkatli takip gerektiren orta ila şiddetli komplikasyonlar bildirildi.

Sonuç: Çalışma sonuçları, titanyum enstrümentasyon ile yapılan PSF'nin çocuk NMS hastalarında takip döneminde tatminkar sonuçlar ortaya koyduğunu göstermiştir. Bununla birlikte, NMS hastalarında titanyum enstrümentasyon ile yapılan PSF'nin sonuçlarını genelleştirmek için daha geniş ölçekli çalışmalara ve uzun dönem sonuçlara gereksinim vardır.

Anahtar sözcükler: Nöromusküler; posteriyor spinal füzyon; skolyoz; titanyum.

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Compared to other forms of spinal deformities in children, neuromuscular scoliosis (NMS) is not very common. However patients with NMS have different challenges related to functional activities and need improvement in physical function with a stable, compensated spine and a balanced torso over a level pelvis. For NMS, Harrington rods with sacral fixation and Luque segmental spinal instrumentation were previously used. Recently, the unit rod became popular with segmental sublaminar wires and control of pelvic obliquity. The evolution of segmental instrumentation techniques across the sacropelvic junction has resulted in better outcomes in this patient population.[1-3]

Regardless of the type and nature of scoliosis, correcting the deformity and maintaining correction are the major endeavors. Stainless steel and titanium alloys are major options of instrumentation with different biomechanical features. Wedemeyer et al.[4] concluded that rod surface stress and fatigue failure risk were lower for the titanium rods in an in vitro study. In another in vitro study, Gurappa[5] reported that stainless steel has lower resistance to fatigue and greater corrosion levels than titanium. However, it is not fully understood if titanium instrumentation provides similar or more benefits in terms of outcomes and complications in patients with NMS.

This current study aimed to characterize the outcomes of posterior titanium instrumentation and fusion in patients with NMS, mainly spinal deformity correction and maintenance of correction.

PATIENTS AND METHODS

Institutional Review Board approval was obtained to conduct a descriptive study to assess the outcomes of posterior spinal fusion using titanium instrumentation in patients with NMS.

This study sample comprised nine NMS patients (5 girls, 4 boys; mean age 14.9±2.3 years; range 11 to 19 years) who underwent surgery between January 2002 and December 2004. The mean height at surgery was 154.6±14.2 cm (range 136-173 cm) and the mean weight was 59.4±19.2 kg (range 26-114 kg) (Table I). The mean follow-up duration was 3.7 years (range, 2-5 years). In this study, the surgical indication was mainly curve progression which was also the main inclusion criteria.

The design used in this study involved a retrospective review of charts and radiographs. Data were collected on preoperative, intraoperative, and postoperative measures. The preoperative data included demographics, curve type, and surgical indication. Intraoperative data included rod size, fusion levels (upper and lower), operative time (min), estimated blood loss (cc), and length of stay (days). Postoperative data included the Cobb angles and complications. Radiographic measurements were obtained from standing posterior-anterior and lateral spinal radiographs at preoperative, first erect, and last follow-up visits. The main curve was measured by the Cobb method.[6] Upper and lower levels for fusion were assessed for each patient.

Statistical analysis

To assess demographics, pre- and postoperative variables, descriptive statistical methods (mainly frequency, percentages, mean, standard deviation (SD), median and range) were used. To determine which summary measures will be adequate in describing the data (continuous variables such as age and Cobb angle), normality test was performed using the Shapiro-Francia test. STATA version 12.0 was used to perform the analysis (STATACorp, TX).

RESULTS

These results represent the findings on the outcomes of posterior spinal titanium instrumentation with fusion among children with NMS. All patients with NMS who underwent surgery were assessed and characterized by preoperative, intraoperative, and postoperative measures.

A 5.5 mm rod size was used in all of the patients for instrumentation. The level of fusions was between T1 and S1. The average time for surgery was 383.4±75.1 minutes (range, 269-511 minutes) and approximate

TABLE I

Study characteristics of patients with neuromuscular scoliosis

	Age (years)	Height (cm)	Weight (kg)
Mean	14.88	154.64	46.33
Standard deviation	2.31	14.18	20.35
Minimum	11	136	30
Maximum	19	173	82

TABLE II

Summary of perioperative data of patients with neuromuscular scoliosis

	Hospitalization (days)	Operative time (minutes)	Estimated blood loss (cc)
Mean	4.88	383.42	2111.88
Standard deviation	2.57	75.08	1692.22
Minimum	1	269	700
Maximum	8	511	5900

blood loss (cc) was 2111.9±1692.2 cc (range, 700-5900 cc). The mean duration of hospital stay was 4.9±2.6 days (range, 1-8 days) (Table II).

We assessed the preoperative, first erect and at least second year postoperative Cobb angle to determine the outcome (effectiveness) of surgery in correcting the deformities and maintaining correction in our sample. Posterior titanium instrumentation substantially improved spinal deformities associated with NMS (Figure 1a-f). The preoperative Cobb angle was reduced from 69.7 degrees to 16.2 degrees at first erect with a remarkable correction of 77%. This correction was not lost at two years follow-up (14.8 degrees) (Table III).

Table IV presents the complications following surgery observed at first erect, six months, first year, second year and after two years of follow-up. The main complications in the first erect period were chest pain, decreased stride, and limb length discrepancy lurch. We observed complications in six of nine patients during this period. During the six month visit, five out of nine patients had complications which included thoracic kyphosis and pelvic obliquity/shoulder elevation. At the first year, six patients presented with complications which included instrument prominence and moderate femoral anteversion. In the second year of follow-up, there were five patients with complications which included body tilt and limited bending. After two years of follow-up there were some complications which were mainly pain.

DISCUSSION

The aim of this study was to assess the outcomes of posterior spinal fusion with titanium instrumentation among pediatric NMS patients. There were some remarkable findings. First, titanium instrumentation demonstrated good outcomes in our sample by substantially decreasing the postoperative Cobb angles and maintaining the correction thereafter. Secondly, there were some important complications which needed careful management.

Surgical success in the treatment of spinal deformities depends on several factors such as approach (anterior/posterior/both), spinal instrumentation, release techniques, and graft.[7] All of the instrumentation systems and materials have advantages and disadvantages. Stainless steel instrumentation has been widely used by surgeons for decades and recently, titanium has been adapted for use in deformity. The main advantages of titanium include compatibility with magnetic resonance and computed tomography imaging,[8] less corrosion,[9-11] and reduced allergenicity[12] and fibrogenicity.[13,14]

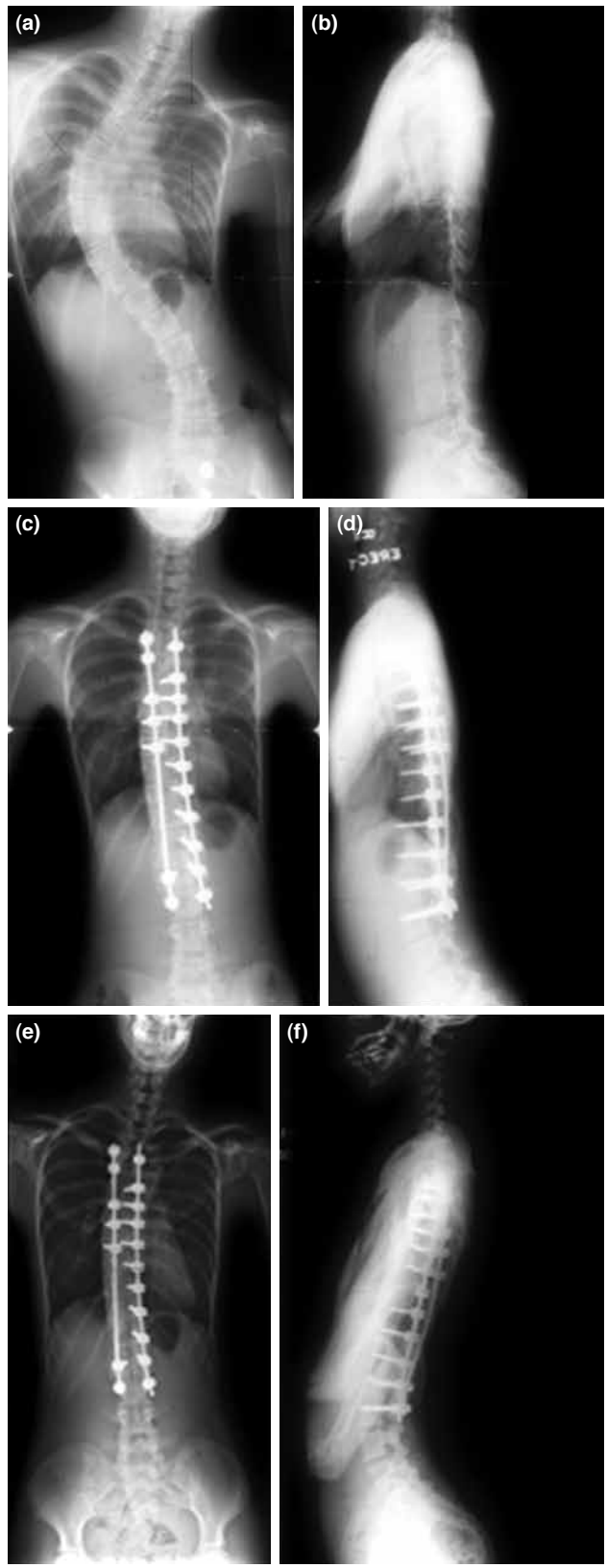

Figure 1. Preoperative X-ray, **(a)** posteroanterior, **(b)** lateral. Postoperative X-ray (first erect), **(c)** posteroanterior, **(d)** lateral Postoperative X-ray (5 years follow-up), **(e)** posteroanterior, **(f)** lateral.

TABLE III

Preoperative and postoperative Cobb angles and deformity correction

	Preoperative Cobb angle (degree)	First erect Cobb angle (degree)	Postoperatif 2 years Cobb angle (degree)	Correction percentage
Mean	69.71	16.2	14.75	77
Standard deviation	23.99	8.8	4.26	11.50
Minimum	44	3	10	64
Maximum	110	26	22	93

TABLE IV

Complications following spinal surgery in patients with neuromuscular scoliosis

Complications	First erect	Six months	First year	Second year	2+ years
Hip pain	1			1	
Groin pain					1
Thigh pain					1
Chest pain	1				
Limb length dicrepancy lurch	1				1
Mild pneumonia	1		1		
Decreased stride	1				
Pelvic obliquity/shoulder elevation	1	1	1		
Thoracic kyphosis		1			
Lumbar paraspinal mass		1			1
Generalized back pain		1	1		1
Mild weakness of quadriceps/hamstrings		1			
Instrument prominence			1	1	1
Moderate femoral anteversion			1		
Beats of clonus				1	
Body tilt			1	1	1
Limited bending				1	
Recurrent windswept deformity					1

The numbers refer to the frequency of complications presented and observed after surgery.

There is even some evidence about titanium inhibition of polymorphonucleocytes[15] and bacterial glycocalyx that may be resistant to infection.

To our knowledge, there are no studies that specifically focused on NMS, using titanium for posterior instrumentation in spinal deformity correction. This study has clearly demonstrated the effectiveness of this surgery in NMS. Curve correction was maintained within satisfactory ranges at the two-year postoperative period. We have also indicated complications that can be encountered. The complications seen in NMS patients after surgery could be moderate to severe and may be difficult to manage. Consequently, caution is required in the selection of this surgical procedure, given these complications.

This study has some limitations as well as its strengths. Primarily, we are unable to generalize the findings due to a small sample size. Therefore with this small sample size, and the tendency towards sparse data bias, caution is required in the interpretation and application of these findings in surgical decision making regarding NMS.

In conclusion, posterior spinal fusion with titanium instrumentation in pediatric NMS patients demonstrated a favorable outcome in the follow-up period of our study sample. Further studies with larger sample size and long-term follow-up results are needed to generalize the findings regarding posterior titanium instrumentation in these patients.

Declaration of conflicting interests

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