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ORIGINAL STUDY

Progressive correction of severe spinal deformities with halo-gravity traction

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Treatment of rigid and severe spinal deformities is challenging and risky. Preoperative halo-gravity traction can be used to progressively reduce the deformity before spinal fusion. The aim of this study was to evaluate the effectiveness of halo-gravity traction for the correction of severe spinal deformities. Fifteen patients were reviewed retrospectively. Their mean age at the beginning of traction was 13.5 years. The mean duration of traction was 64 days. The main curve in the coronal plane improved from +/- 95° to +/-67°, a gain of +/-28° (range 0°-50°) or +/-30%. The curve in the sagittal plane improved from +/- 96° to +/- 78°, a gain of +/- 18° (range 0°-45°) or +/-19%. Other authors report gains up to 46% and 43%, respectively in the coronal and in the sagittal plane, but this might be due to different conditions, techniques, and evaluations. One patient with a pre-existing neurological deficit developed paraplegia. According to the literature congenital curves with associated kyphosis are exposed to paraplegia. Halo-gravity traction is effective and is usually tolerated better than other techniques of traction using the halo device.

Keywords : spinal deformity ; preoperative halo-gravity traction.

INTRODUCTION

Severe spinal deformities are relatively rare. Most often only partial correction is obtained. Moreover, there is a high risk of neurologic complications (*11*). Preoperative treatment should aim at a maximum of correction with a minimum of neurological complications (*21*). The halo device, introduced by Nickel *et al* (*14*), allows to apply effective traction via the skull. It has been used in various ways : halo-pelvic, halo-femoral, halo-tibial (*2,8,10, 15*) and halo-gravity traction, introduced by Stagnara (*20*). The aim of this study was to evaluate the effectiveness of the halo-gravity traction.

MATERIAL AND METHODS

The authors conducted a retrospective study on all patients treated by halo-gravity traction and spinal fusion between January 2009 and December 2010. The study only focused on the correction of the Cobb angles obtained *after* traction, but *prior to* spinal fusion. All patients had a rigid deformity defined as a reduction of the main curve of less than 20% on lateral bending films or on traction films.

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Fig. 1. — Case 4. Halo-gravity traction via a spring scale, on a wheelchair, in an 18.5 year old girl. The straps between halo and spring scale were shortened to increase the traction.

Halo-gravity traction technique

The halo device was applied in the operating room under general anaesthesia. Eight to 10 pins were used, depending on the child's body weight and head circumference. Pins were inserted without hair shaving. No dressing was applied around the pins. Traction via a spring scale (Fig. 1) was usually started one day after halo application, mostly on a wheelchair, though occasionally on a standing frame. The spring scale allowed to measure the amount of traction (*18*). The initial traction amounted to 10-20% of body weight. It was increased at a rate of 1 kg per day, without exceeding 50% of total body weight, by shortening the straps between halo and spring scale. The traction was applied for at least 12 hours a day. At night it was reduced to 10% of body weight. Tolerance of traction, pin insertion sites and neurological status were checked on a daily basis. Correction of the curve was evaluated by weekly antero-posterior and lateral plain radiographs of the entire spine with the patient under traction. A lateral cervical radiograph was also routinely made to check for cervical complications. In two cases traction was continued on an outpatient basis after having reached the maximum amount of traction ; patients and parents were briefed about possible complications. The traction was discontinued when correction was deemed sufficient to perform an effective and non-risky posterior fusion, possibly with further correction, or when correction reached a plateau on two consecutive radiographs.

RESULTS

Fifteen patients (Table I) underwent halo-gravity traction and fusion for severe spinal deformity from January 2009 to December 2010. There were 10 girls and 5 boys. Traction started at an average age of 13.5 years (range 5-18.5 years). The average duration of traction was 64 days (range 22 to 130 days).

There were 12 cases of kyphoscoliosis, 2 cases of scoliosis and 1 case of lordoscoliosis. The aetiology was varied (Table I).

Two patients with a congenital scoliosis (Table I) had undergone spinal surgery before traction. The first patient had undergone a posterior arthrodesis, which had failed to stop the progression of the deformity, and the other one had had a hemi-epiphysiodesis. Prior to traction an attempt at correction had been made with instrumentation without fusion in 2 patients (*12*) (Table I), and with a turnbuckle cast (*3*) in 4 other patients. The turnbuckle cast had to be removed in 2 patients, in one case because of pressure sores over the gibbus and the iliac crests, and in the other case because of brachial plexus palsy.

Table II shows the radiographic data in the coronal and sagittal plane before and after traction. Before traction the average Cobb angle of the main curve *in the coronal plane* was 94.86° (range 40°-130°) ; after traction it improved to 66.53° (range 32°-90°) : a gain of 28.33° (range 0°-50°) or 29.86% (range 0%-45%). The maximum correction obtained after traction was 45%. Three patients showed a correction less than 10°. Two of them had

Table I. — Patients' data

	Age (year)	Gender	Type of deformity	Aetiology	Previous surgery	Previous traction	Duration of traction (days)	Compli-cations	Final treatment
1	13	Female	Lordoscoliosis	Escobar syndrome	–	–	52	–	Anterior osteotomy - posterior fusion with instrumentation
2	13	Female	Kyphoscoliosis	Juvenile idopathic	–	–	43	–	Posterior fusion with instrumentation
3	17.5	Male	Kyphoscoliosis	Juvenile idiopathic	–	yes	78	–	Posterior fusion without instrumentation
4	18.5	Female	Scoliosis	SCIWORA syndrome	–	–	57	–	Anterior release - posterior fusion with instrumentation
5	12	Female	Kyphoscoliosis	Juvenile idiopathic	Instrumen-tation with-out fusion	yes	56	–	Anterior release - posterior fusion with instrumentation
6	14	Female	Kyphoscoliosis	neuromuscular	–	–	62	Spastic paraplegia	Anterior release - posterior fusion with instrumentation
7	17.5	Female	Kyphoscoliosis	Marfan Syndrome	–	–	33	–	Posterior fusion with instrumentation
8	16.5	Male	Kyphoscoliosis	syrinx	–	–	70	–	Anterior release - posterior fusion with instrumentation
9	16.5	Male	Kyphoscoliosis	Marfan syndrome	–	–	22	–	Posterior fusion with instrumentation
10	17	Female	Kyphoscoliosis	Skeletal dysplasia (not specified)	–	yes	131	–	Anterior release - posterior fusion without instrumenta-tion
11	14	Female	Scoliosis	congenital	hemiepi-physiodesis	–	87	Pin infec-tion and loosening	Posterior fusion with instrumentation
12	13.5	Female	Kyphosoliosis	neuromuscular	–	–	66	–	Anterior release - posterior fusion with instrumentation
13	5	Female	Kyphoscoliosis	Congenital kyphosis	Posterior arthrodesis	–	75	–	Anterior strut graft
14	10.5	Male	Kyphoscoliosis	Infantile	–	–	74	–	Posterior fusion without instrumentation
15	12.4	Male	Kyphoscoliosis	Spondyloepiphyseal dysplasia	Instrumen-tation with-out fusion	yes	60	–	Posterior fusion without instrumentation

had previous spinal surgery (cases 11 and 13). The improvement was greater than 30° in 10 out of 15 patients, or 66%. In *the sagittal plane* the average pre-traction Cobb angle was 96.38° (range 80°-120°). After traction it improved to 78.30° : a gain of 18.08° (range 0°-55°). The improvement was less than 10° in eight patients. Three patients did not show any improvement in the sagittal plane.

The predominant complication was cervical pain (4 patients), mainly at night. This necessitated a temporary reduction of the traction, which was followed by the disappearance of the complaints. In

Table II. — Radiographic measurements

	Main coronal curve				Sagittal Curve			
	Pretraction value (°)	After traction (°)	Amount of correction (°)	Percentage of correction (%)	Pretraction value (°)	Value after traction (°)	Amount of correction (°)	Percentage of correction (%)
1	115	85	30	26	100	78	22	22
2	110	65	45	40	85	70	15	17.5
3	80	80	0	0	80	80	0	0
4	108	70	38	35	–	–	–	–
5	108	70	38	35	80	60	20	25
6	72	58	14	19	90	80	10	11
7	130	80	50	38	90	90	0	0
8	106	74	32	30	90	90	0	0
9	90	50	40	44	98	90	8	8
10	130	90	40	30	95	40	55	58
11	40	38	2	5	–	–		–
12	116	80	36	31	100	64	36	36
13	40	38	2	5	115	106	9	7
14	120	88	32	26	120	100	20	16
15	58	32	26	45	110	70	40	36
Average	94.86	66.53	28.33	29.86	96.38	78.30	18.08°	18.67

one of our first patients (case 11), in whom only four pins had been used, superficial infection and loosening at one pin site necessitated a pin change. One patient (case 6) with signs of neurological deficit existing before traction developed a spastic paraplegia while in traction, which further worsened after posterior spinal fusion.

DISCUSSION

The deformed spine is viscoelastic, which allows a progressive correction when external traction is applied, as has been stated by Clark *et al* (*1*).

Correction

The correction obtained in the current series (29.86% in the coronal plane, and 18.67% in the sagittal plane) was less than previously reported in literature. Of course, it is difficult to compare studies, because of differences in technique and evaluation. Sink *et al* (*18*) reported an average improvement of 35% in the coronal plane and of 26% in the sagittal plane, in 19 patients. These results were better than those obtained in the current study, but this might be due to the combination with vertebral osteotomies or anterior release prior to or during traction. Rinella *et al* (*17*) reported an improvement in the major coronal and sagittal curves of 46% and 43% respectively, in 33 patients, but after traction *and* fusion. This did not reflect the actual gain obtained with traction only. Topouchian *et al* (*23*) reported a 37% improvement in 27 patients with osteogenesis imperfecta, after halo-gravity traction and *in situ* posterior fusion with instrumentation. In contrast, Sponseller *et al* (*19*) did not find any significant difference between traction and non-traction. However, the non-traction group had more frequently been treated with a vertebral column resection. We can confidently assume that the preoperative traction in some cases avoided the need for a vertebral column resection, a challenging and demanding technique to correct severe and rigid spinal deformities (*9*). However, Flierl and Carstens (*5*) do not recommend halo-gravity traction for the treatment of neuromuscular scoliosis.

Pulmonary status

Improvement of the pulmonary status in these patients, who may have restrictive lung disease (*22*), has been reported after halo-gravity traction (*18,23*). Topouchian *et al* (*23*) reported a 15% increase in the vital capacity after traction. Sink *et al* (*18*) recommended monitoring of the pulmonary function as well as the spinal correction as a way to determine when to discontinue the traction.

Pins

Problems related to pin fixation and loosening are often reported (*23*). They can be avoided by the use of many pins. At least 8 pins were used in the current study. This multiple pin fixation, as described by Mubarak *et al* (*13*), decreases the stress on each pin and the risk of infection and loosening (*23*). Brain abscess, due to penetration of a pin through the inner table of the skull, has also been reported (*6*). Again, this complication can be avoided by the use of multiple pins allowing the application of a lower insertional torque (*13*).

Neurological complications

Neurological complications may also occur during skeletal traction (*11,24*). In the current series traction aggravated a pre-existing neurological deficit in one patient (case 6). MacEwen *et al* (*11*) reported 6 cases of paraplegia following halo-pelvic or halo-femoral traction, mainly in patients with congenital kyphoscoliosis with a severe kyphosis component. Other neurological complications reported after skeletal traction include brachial plexus palsy (*16*) and cranial nerve palsy, especially the sixth cranial nerve, and less often the ninth, tenth and twelfth nerve (*24*). These complications are much more common with halo-pelvic or halo-femoral traction which use a higher and more constant level of traction, but have also been reported after halo-gravity traction (*7*). Sink *et al* (*18*) hypothesized that the use of a spring, without weights, as in the current study, might explain the rarity of cranial nerve complications because it allows the patient to rise up and relieve traction when uncomfortable.

Cervical complications

Severe cervical complications are well known after skeletal traction (*4*), but were not seen in the current series. Yang and Sponseller (*25*) reported a case of progressive cervical kyphosis which developed several months after treatment. Sink *et al* (*18*) reported a case of cervical distraction through the only non-fused segment of the neck in a patient with Klippel-Feil syndrome. However, cervical complications are much less common after halo-gravity traction than after halo-pelvic or halo-femoral traction (*4*). This might be explained by the preservation of cervical mobility and the lower amount of traction used with the halo-gravity traction.

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