



Femoral Fractures in Infants : A Comparison of Bryant Traction and modified Pavlik Harness

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Bryant traction is a commonly used method for femoral shaft fractures in children, but many disadvantages have been reported. Pavlik harness with exact clinical effect and fewer complications has gained increasing popularity in recent years. The objective of this study was to evaluate and compare modified Pavlik harness with Bryant traction for infant with a femoral shaft fracture.

A retrospective study was performed of 38 infants treated with either modified Pavlik Harness or Bryant traction. All fractures were closed, isolated, and diaphyseal. We analyzed operative and radiographic data, complications, hospital charges, and functional outcome.

Twenty-one patients, with a mean age of 5.9 months, were treated with modified Pavlik harnesses. Seventeen infants, with a mean age of 6.3 months, were treated with Bryant tractions. All fractures united within 3-5 weeks. The two cohorts were similar with respect to age, weight, and fracture union time. Four of the seventeen children treated with Bryant tractions had a skin complication that needed second intervention. No similar complications occurred in the modified Pavlik group ($p = 0.03$). There was a significant difference in hospital stay (modified Pavlik harness 1.4 days versus Bryant traction 17.8 days) and hospital charge (modified Pavlik harness 3209 Yuan versus Bryant traction 3759 Yuan) ($p < 0.001$). At one year visit, no difference existed between the two groups for standard clinical/functional criteria. There were no malunion, nonunion, or rotational deformities. Nor were there any significant limb length discrepancies, residual angular deformities.

Key words: Infants, fracture of femoral shaft, modified Pavlik harness, Bryant traction.

INTRODUCTION

Closed femoral shaft fractures are common in infants (< 1 year) (1). Nonsurgical treatment remains the preferred and the most cost-effective management for infants with an isolated femoral fracture. A variety of treatment methods have been reported, including immediate spica casting (2-4), skin traction (5-7) like Bryant traction (8), and Pavlik harness (9). Pavlik harness which was used to treat developmental dysplasia of the hip (DDH) was first introduced by Stannard *et al* (10) for the treatment of femur fractures. This system provides adequate alignment and comfort for proximal and middle-

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Fig.1. — A baby, female, 10 months old, with right femoral shaft fracture treated by modified Pavlik Harness.

third shaft fractures and avoids the potential skin problems associated with using a spica cast (11). In this study, we provide a modified Pavlik harness which appears to have a metal bar that prevents excessive abduction (Fig. 1). There have been no other published reports directly comparing this technique to Bryant traction. This study is to evaluate and compare the hospitalization, fracture union time, complications, leg-length discrepancy, angulation, and charge for infants with femoral shaft fractures treated by these two methods.

PATIENTS AND METHODS

Institutional review board approval was obtained before the study. We enrolled a computerized search of clinical records for the purpose of identifying all infants with isolated femoral diaphyseal fractures who had been managed with a modified Pavlik harness or Bryant traction from June 2006 to March 2011 at Department of Orthopaedics, the Second Affiliated Hospital of Wenzhou Medical University. All fractures were with less than 2 cm of initial shortening. The exclusion criteria included any fractures that had >2cm shortening, open fractures, multiple long-bone fractures of the lower extremity or metabolic bone disease, pathologic fracture, or underlying neuromuscular disease.



Fig. 2. — Ten month old female with fractured right femur treated with modified Pavlik Harness. a : Lateral radiograph of the patient at the time of presentation. b : Lateral radiograph of the patient soon after the reduction. c, d : Anteroposterior and Lateral radiograph of the extremity after 2 weeks fixation. e, f : Anteroposterior and Lateral radiograph of the extremity at union. g, h : Anteroposterior and Lateral radiograph at one year follow up.

A total of 42 patients met the inclusion criteria for the present study. All the fractures were closed, uncomplicated and no pathological fracture occurred. Four patients (9.5%) were excluded because of inadequate follow-up. Thus, 38 patients finished at least one year follow-up, with an average of 19.6 months (range from 12 to 26 months). Twenty-one (fourteen boys and seven girls) were managed with modified Pavlik Harness and seventeen (twelve boys and five girls) were applied with Bryant tractions. The mean age of the patients was 6.1 (0-12) months. There was no significant difference between the groups with respect to age and body weight. Among the fractures, 24 (63%) were located at the mid-diaphysis, 12 (32%) were proximal, and 2 (5%) were distal. According to characteristics of the fracture line, 20 were transverse (52.6%), 13 were oblique (34.2%), and 5 were spiral (13.2%) (Table II).

The children treated with Bryant tractions were supine with the hips flexed 90°, the legs being pulled directly upwards. The weight applied should be sufficient to allow the surgeon to slip their hand underneath the nappy, but no more, bone protrusion protected by pad cotton and blood circulation of the lower limbs should close observation, avoiding compression of common peroneal nerve, with or without blood vessels or nerve compression symptoms, adjusting traction device if necessary. The skin of the legs is examined every day, ini-

Table I. — Acceptable Angulation and Shortening in Children with a Femoral Fracture at Union*

Age	Varus/Valgus Malalignment (deg)	Anterior/Posterior Malalignment (deg)	Shortening (mm)
Birth to < 2 yr	30	30	15

* Based on data from : Flynn JM, Skaggs DL. Femoral shaft fractures In : Rockwood CA, Wilkins KE, Beaty JH, Kasser JR. Rockwood and Wilkins' fractures in children. 7th ed. Philadelphia : Lippincott Williams & Wilkins ; 2010. p 805.

Table II. — Patient Characteristics of the Two Groups

	Bryant (n = 17)	modified Pavlik (n = 21)
Average age(Month)	6.3	5.9
Average weight(kg)	7.9	7.4
Location		
Proximal	5	7
Middle	10	14
Distal	2	0
Type		
Transverse	9	11
Oblique	6	7
Spiral	2	3

tially with careful reapplication of the bandaging. The traction period was 2-4 weeks depending on the child's age. We take radiographs routinely in the first two weeks. After the traction device was removed, the patients were discharged, but they went on wearing a splint until stable union was obtained.

The modified Pavlik harnesses were applied in combination with the use of intravenous pain medication. The affected hip was flexed at 80° to 90° and abducted at 50°. After wearing Pavlik harness, children underwent X-ray examination to check the position of the fracture site. The patient typically spent 24 hours in the hospital for observation. Patients were routinely seen in the clinic 1 week, 2 weeks, and 4 weeks after fixation. Standard anteroposterior (AP) and lateral radiographs were also obtained at each visit.

After the harness or traction was removed, each patient returned for follow-up at 1 month, 6 months, and then annually. Fracture union time was defined as the time to a stable callus formation reviewed clinically and radiologically (12). At the above time points, leg length and possible rotational deformity was checked clinically and angular deformity was measured on the radiograph. Malunion was determined to be present if femoral angulation and shortening did not meet the criteria established by Kasser *et al* (Table I) at the time of harness or traction removal.

Statistical Methods

Results are expressed as mean and range values. Data (age, weight, duration of hospital stay, time to fracture union, leg length discrepancy, charge data and angulation) were compared between the two groups with the Student t test or Mann-Whitney test. Comparisons of count data (gender, location and types of femoral fracture and skin complication) were done with the fisher exact test. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) Version 18.0. P values below 0.05 are considered statistical significance.

RESULTS

The average hospital stay for patients in Bryant traction was 17.8 days (14-25), compared to 1.4 days (1-3) for those with modified Pavlik harness. The difference in the average hospitalization of the groups was statistically significant ($p < 0.0001$). No patient required additional open reduction during the follow-up.

The mean fracture union time in modified Pavlik harness group was 3.7 weeks and in Bryant traction was 4.1 weeks. At the latest follow-up, the range of motion of knees and hips were normal for both groups, and there were no instances of malunion, refractures' nonunion, or rotational deformities.

Skin complications occurred in four children in Bryant traction group, but none were observed by using the modified Pavlik harness. Slough over the knees or thighs were found due to irritation by the traction at the time of fixation removal. All the skin lesions healed rapidly after local treatment except one that developed pressure sore with infection, treated with local wound care and oral Amoxicillin (Penicillin).

Table III. — Outcomes of the Two Groups

	Bryant (N = 17)	modified Pavlik (N = 21)	P Value
Average hospital stay(days)	17.8	1.4	0.00*
Average fracture union time(weeks)	4.1 ± 0.9	3.7 ± 0.8	0.22*
Skin complications	4	0	0.03#
Leg-Length Discrepancy(mm)	8.0	7.6	0.92*
Angulation(deg.) 5.2	6.3	0.74*	
Charge Data(¥) 3759	3209	0.00*	

* Student t test. #Fisher exact test

The mean leg length discrepancy at the time of initial closed reduction was 7.6 mm following treatment with a modified Pavlik harness compared with 8.0 mm following treatment with a Bryant traction ($p = 0.92$). The mean leg length discrepancy at the time of one year follow-up was 3.9 mm following treatment with a modified Pavlik harness compared with 3.0 mm following treatment with a Bryant traction. None had a discrepancy of over 15 mm.

At the time to reduction, 12 patients showed a angular deformity of $> 5^\circ$, among 4 patients had a varus/valgus angulation of $> 15^\circ$ and the maximum angular deformity was 23° in modified Pavlik harness group. On the other side, 9 patients showed a angular deformity of $> 5^\circ$, among 2 patients had a varus/valgus angulation of $> 15^\circ$ in Bryant traction group. One year later, no patient had a angular deformity more than 15° in both groups. The mean angular deformity was 6.3° in modified Pavlik harness group and 5.2° in Bryant traction group. There was no statistically significant between two groups.

The charges for treatment were calculated by tallying the inpatient and outpatient charge data of each patient from the injury until the time of final follow-up. The total cost comparison between patients treated by modified Pavlik harness at the average of 3209 yuan and Bryant traction at the average of 3759 yuan. The difference was statistically significant ($p < 0.0001$) (Table III).

DISCUSSION

The etiology of femoral fractures in infants is various including child abuse, falls, and motor vehi-

cle collisions (13-15). There are many areas of consensus and controversy among the managements of femoral shaft fractures in children (16-18). The method of treatment depends on the age of the patient (19, 20). In the past decades, traction and cast were thought as the classic treatment for femoral shaft fractures in children. Pediatric femoral shaft fractures create substantial short-term disability, these injuries can generally be treated successfully with few long-term sequelae, and nonoperative approaches were considered first.

The Pavlik harness, which has been initially used to treat developmental hip dysplasia, was popularized by Stannard *et al* (10) for femoral shaft fractures in infants. Advantages for infant femur fractures with a Pavlik harness includes application easily, ease of nursing care and diapering, minimal hospital stay, ability to adjust the harness and fracture reduction if fracture manipulation is required, and minimal cost. We used a modified Pavlik harness that easier for application and prevents excessive abduction which may more comfortable for child.

Since initially reported by Bryant in 1873, Bryant traction has been successfully used in treatment of femoral shaft fractures of children under 3 years of age (21) and congenital dislocations of the hip (22), regarded as a simple and effective non-surgical treatment. Nevertheless, it often resulted in vascular insufficiency like Volkmann's ischaemia, skin slough and equinus contracture (23-25).

Our study retrospectively analyzed 38 femoral fractures in infants treated with a modified Pavlik harness or Bryant traction. The main problem with

conventional traction was potential complications. Skin complications, such as slough and blistering, are common. Esenyel *et al* (7) reported a skin lesion in their series of 207 children, and excoriations were documented by Givon *et al* (26). In our study, there were four patients with slough, even one developed pressure sore required additional treatment. Traction has been associated with vascular problems, including severe compartment syndrome and Volkmann's ischaemic contracture (27). Those disadvantages had led many pediatric surgeons abandon classic Bryant traction. In our study, no skin complications were found in the modified Pavlik harness group.

Angular deformity was frequently reported in many literatures (4,28,29) in children after femoral shaft fractures, but this usually remodels with growth. Flynn (30) viewed that acceptable the angulation for children younger than 2 years was 30° in the frontal plane (valgus/varus), 30° in the sagittal plane and the shortening of < 15 mm at union. Over half patients (57%) had angular deformity in our study and the maximum angular deformity was 23° in modified Pavlik harness group, but no patient had a angular deformity more than 15° at one year visit and no instances of rotational deformity. Two groups did not show any significant difference in outcomes.

The most common sequela is leg-length discrepancy, resulting from the initial overriding of the fragments and/or from the overgrowth phenomenon in the fractured limb (31). Due to the strong potential for bone union and remodeling, the maximal acceptable shortening in infants is approximately 15 mm at union (30). In our study, the final leg length discrepancy was all shorter than 10mm, and there were no significant differences between two groups. At the latest follow-up, there were no patients with noticeable leg length discrepancy that might lead to functional impairment.

The major drawback of Bryant traction in hospital is the unduly long hospitalisation. Average hospital stay for patients in Bryant traction was 17.8 days. The mean hospital stay of the fractured femur has been shown to be 22 days by Scheerder *et al* (8) and 19 days by d'Ollonne *et al* (6). However, patients treated with modified Pavlik harnesses

spent only 24 hours in the hospital for observation, then they returned home and periodically reexamined in outpatient.

Numerous literatures (3,12,32), that compared the cost of traction and immediate hip spica casting, have demonstrated that conservative traction needed significantly higher patient charges. Due to duration of hospital stay in Bryant traction group, it is no surprise about the very different costs between two treatment modalities. Isolated and undislocated femoral shaft fractures could be treated in an outpatient clinic with modified Pavlik harness. We could only estimate the total direct medical costs (the cost of hospitalisation, X-rays and follow-up medical visits). The indirect costs (including those for transportation, time off from work and other costs) as charge data are not always an accurate reflection of true costs to the patient. Furthermore, cost is not a major factor to determine the choice of treatment at our hospital.

Our indications for treatment of femur fractures in infants with the modified Pavlik harness include fractures of the proximal and middle thirds of the femur, younger than 12 months old at the start of treatment, body weight < 15 kg, or shortening of < 2 cm. In our study, we recommend that a child with the body weight heavier than 15 kg should not be treated by the modified Pavlik harness because too heavy may put too much pressure on the posterior aspect of the thigh and knee.

Several limitations of this study should be noted. Firstly, we could not randomize the treatment method as we cannot rule out the possibility of a selection bias favoring one type of treatment. Secondly, our study was conducted at a single institution, thus with small sample size there may be some deviations with other surgeons. Finally, it is difficult to achieve the exact cost of treatment, as we could only estimate the total direct medical costs excluding indirect costs.

In summary, our retrospective review of comparable patients demonstrated no discernible differences in fracture union time, leg length discrepancy, or angulation when comparing the modified Pavlik harness group with the Bryant traction group, but easier application, easier nursing care and diapering, lower hospital stay, and lower cost

treat with modified Pavlik harnesses. We think that it is safe and effective for patients with the modified Pavlik harnesses that lead to a satisfactory outcome, and it should be considered an acceptable method of immobilization.

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