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# Indicators of successful use of the Pavlik harness in infants with developmental dysplasia of the hip

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**Abstract** This study examined the outcomes of ultrasound-monitored Pavlik harness treatment in 25 infants (2 boys and 23 girls) representing a total of 31 cases of developmental dysplasia of the hip of Graf type IIc or more severe. For all infants, Pavlik harness treatment started after ultrasonographic diagnosis in our clinic. If there was no improvement by the third week of follow-up, the harness treatment was discontinued. Of the 25 patients (31 hips), 16 patients (18 hips) were successfully treated with the Pavlik harness. The effects of age at start of treatment, gender, side of pathology, first clinical evaluation findings, bilaterality, and Graf type on Pavlik harness treatment success were analysed. We found that the outcome of treatment with the Pavlik harness was related to Graf type, age at start of treatment, and bilaterality.

**Résumé** Etude du traitement par harnais de Pavlik, avec contrôle par ultra-sons, de 31 dysplasies de hanche de type IIc ou plus selon Graf, chez 25 enfants (2 garçons et 23 filles). Dans tous les cas le traitement a débuté après un diagnostic ultrasonographique. En cas d'absence d'amélioration à la troisième semaine le traitement était arrêté. Sur les 25 patients, 16 (18 hanches) avaient un succés. Le rôle de l'âge au traitement, du sexe, du côté, de la première évaluation clinique, de la bilatéralité et du type selon Graf étaient étudiés. Nous avons constaté que l'efficacité du traitement par harnais de Pavlik dépend du type selon Graf, de l'âge au début du traitement et de la bilatéralité.

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## Introduction

The prognosis of developmental dysplasia of the hip (DDH) depends on early diagnosis and accurate treatment. Ultrasonography is considered to be a safe method for detecting hip dysplasia within the first months or even days of life, and with Graf's classification, one can decide whether or not treatment is necessary. Most authors investigating hip ultrasonography have noted that it is a superior method for the early diagnosis of DDH [8, 10, 13, 19, 20].

The Pavlik harness was first used by Arnold Pavlik in 1944 for the treatment of DDH [12]. While the Pavlik harness prevents extension and adduction of the hip joint, it allows movements in the safe zone (the arc between the angle of adduction that would allow redislocation, and the angle of abduction that can be comfortably attained) as defined by Ramsey et al. [14]. In this way, spontaneous movements help in the reduction of the hip joint. The major advantages of the Pavlik harness are that it allows spontaneous reduction without rigid fixation, permits ultrasound observation of the reduction (Fig. 1), allows diapers to be changed without its removal, and is inexpensive and easy to use.

The harness is applied with the hips having greater than 90° of flexion, and with adduction of the hip limited to a neutral position. The line of pull of the flexion straps must be lateral enough (e.g., along the anterior axillary line) to effect flexion in a relatively abducted rather than an adducted position [7]. The posterior straps must not be under tension to the point of creating forceful abduction. The function of this strap is not to force the hip into abduction, but to prevent the hip joint from being dislocated by adduction. When abduction is obtained by force there is greater danger of avascular necrosis of the femoral head [6, 18]. A constant oblique posture is also unacceptable. A pillow should be applied under the knees to reduce the angle of abduction and maintain correct posture [6]. Ultrasound has been shown to be highly accurate for evaluation of the position of the hip in a Pavlik harness[15].

Misuse of the Pavlik harness, in addition to presenting a risk of avascular necrosis [6], can also increase the

**Fig. 1** An important advantage of the Pavlik harness is the ability to monitor hip joint reduction by ultrasound when the harness is in place

complexity of hip deformation [7, 16] and may damage the femoral nerve [22] or brachial plexus [17].

Infants born in our obstetrics department are examined in a DDH screening and prevention program during the first 2 days postpartum. For infants who appear to be at risk of DDH according to their medical history and physical examination, we routinely order a nonrigid abduction orthosis. Infants are then re-examined for DDH with ultrasonography as part of their 1-month follow-up visit. In our institution, the Pavlik harness is mostly used as a treatment for DDH in patients classified as Graf type IIc or more severe, diagnosed before the age of 6 months.

This study attempts to determine whether factors such as age at start of treatment, gender, presence of bilateral DDH, side of pathology, initial clinical examination findings, and ultrasonographic classification (Graf type) correlate with successful Pavlik harness treatment.

## Materials and methods

Response to Pavlik harness treatment was monitored via ultrasound in 25 infants (2 boys and 23 girls) who had a total of 31 cases of DDH of Graf type IIc or more severe. All infants were younger than 6 months, and were referred both from our hospital's neonatology department and from

**Table 1** Patients treated with the Pavlik harness

| Patient ID number | Age at initial diagnosis (weeks) | Duration in the harness (weeks) | | Clinical examination | Graf type | Success |
|---|---|---|---|---|---|---|
| | | Full-time | Weaning | | | |
| 1 | 8 | 16 | | Irreducible | IIIa | No |
| 2 | 4 | 7 | 8 | Reducible | IIIa | Yes |
| 3 | 9 | 3 | | Irreducible | IIIb | No |
| 4 | 8 | 3 | | Reducible | IIIa | No |
| | | | | Reducible | IIIa | No |
| 5 | 20 | 10 | 12 | Irreducible | IIIb | Yes |
| 6 | 14 | 6 | 7 | Irreducible | IIIa | Yes |
| 7 | 5 | 8 | 8 | Irreducible | IIIa | Yes |
| 8 | 7 | 3 | | Reducible | IV | No |
| 9 | 13 | 10 | 9 | Stable | IIc | Yes |
| 10 | 4 | 8 | 10 | Irreducible | IIIa | Yes |
| 11 | 4 | 8 | 7 | Dislocatable | IIc | Yes |
| | | | | Dislocatable | IIc | Yes |
| 12 | 7 | 8 | 8 | Stable | IIc | Yes |
| 13 | 5 | 9 | 9 | Dislocatable | IId | Yes |
| 14 | 12 | 10 | | Dislocatable | IIc | No |
| | | | | Dislocatable | IId | No |
| 15 | 5 | 10 | 6 | Stable | IIc | Yes |
| | | | | Stable | IIc | Yes |
| 16 | 15 | 3 | | Irreducible | IIIb | No |
| | | | | Irreducible | IIIb | No |
| 17 | 4 | 11 | 10 | Irreducible | IIIb | Yes |
| 18 | 9 | 3 | | Irreducible | IV | No |
| 19 | 6 | 5 | 6 | Irreducible | IIIa | Yes |
| 20 | 12 | 8 | 7 | Stable | IIc | Yes |
| 21 | 5 | 3 | | Reducible | IV | No |
| | | | | Reducible | IV | No |
| 22 | 6 | 8 | 5 | Stable | IIc | Yes |
| 23 | 10 | 11 | 9 | Stable | IIc | Yes |
| 24 | 16 | 3 | | Irreducible | IV | No |
| 25 | 8 | 8 | 7 | Dislocatable | IId | Yes |

other institutions. For all infants, Pavlik harness treatment was started after ultrasonography to confirm the diagnosis. Patients who were premature or who had neuromuscular dislocations or documented connective tissue disorders were excluded from the study. In all patients, the harness was applied within 3 days of diagnosis.

The sonograms were classified by Graf's method in terms of the α and β angles [1]. All sonograms were evaluated by an experienced ultrasonographer. Each infant's gender, side(s) of pathology, age at start of Pavlik harness treatment, and duration of treatment were recorded. In the clinical examination, hips were graded as stable, dislocatable by the Barlow manoeuvre, reducible (femoral head dislocated but reducible by the Ortolani manoeuvre), or irreducible (Table 1).

After the diagnosis was established, treatment with the Pavlik harness was started. In the first 3 weeks of treatment the parents brought their infants to our clinic weekly, at which time they received instructions and the harnesses were adjusted if necessary. On the third of these visits, the hip positions were examined with ultrasonography. If reduction was not apparent, Pavlik harness treatment was discontinued. For patients in whom the harness provided reduction, harness treatment was continued until sonographic maturation was demonstrated. These follow-up ultrasound evaluations were performed at intervals of 2–3 weeks. This period of continuous use of the harness was followed by a weaning period of part-time harness use or the use of a nonrigid abduction orthosis. Our weaning regimen generally consisted of removing the harness for 2–4 h per day for 2 weeks, then removing it for 4–6 h per day for 2 weeks, followed by a final period of only night-time use of either the Pavlik harness or a nonrigid abduction orthosis. Final follow-up radiographs were made of each patient at 8–18 months after the treatment had ended, and these images were reviewed to determine any evidence of residual dysplasia or avascular necrosis. Treatment success was defined as the achievement of a normal α angle and normal findings on clinical examination. Failure was defined as failure to achieve or maintain hip reduction.

Data were analysed statistically with SPSS for Windows (version 10.0.1, SPSS, Chicago, IL, USA). The results of the treatment were evaluated in binary outcome groups (success or failure). Chi-squared or Fisher's exact tests were used to detect differences in treatment outcomes associated with gender, side of pathology and bilaterality. The Mann–Whitney *U* test was used to see if there were differences in outcomes associated with the infants' age at the start of treatment. Statistical significance was defined as a *p* value less than 0.05.

## Results

Of the 31 hips with DDH, Pavlik harness treatment was successful in 18. In these successfully treated patients, continuous use of the Pavlik harness ranged from 5 to 11 weeks in duration (median 8 weeks). No association was found between treatment success and gender, side of pathology or clinical examination findings. However, successful treatment was found to be affected by age at start of treatment, Graf type and bilaterality. Among the successfully treated patients, no avascular necrosis was seen on follow-up radiographs; however, low-grade acetabular dysplasia was seen in one of these patients. Among these patients, average length of follow-up was 21.5 months (range 8–36 months).

### Age at start of treatment

Age at the time of diagnosis ranged from 4 to 20 weeks (median 8 weeks). A statistical difference was found between successful and unsuccessful Pavlik harness treatment in terms of the infants' age at the start of treatment ($p$=0.032). Infants aged 7 weeks and under had a higher rate of success than those aged 8 weeks and over ($p$=0.038, Fig. 2).

### Graf type

By Graf type, infants with type IIc, IId or III hips had a higher rate of treatment success than infants with type IV hips ($p$=0.008). However, when type IIc or IId hips were considered as a group, no difference was observed between them and type III hips in terms of treatment success (Fig. 3).

### Bilaterality

Patients with bilateral DDH were found to have a lower rate of treatment success than patients who had one-sided DDH ($p$=0.032, Fig. 4).

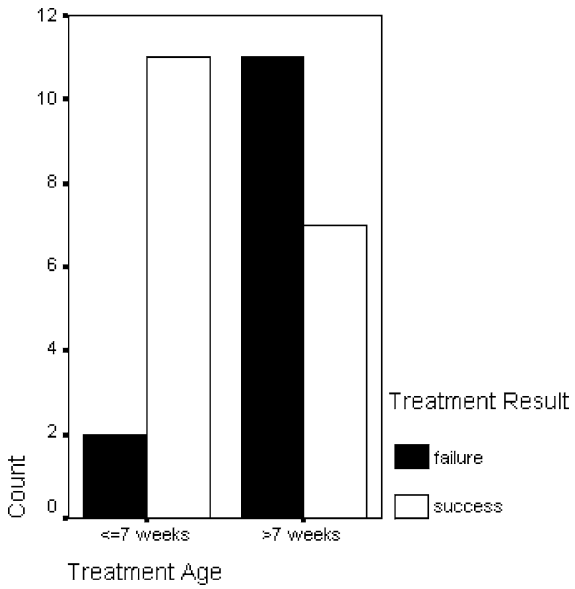


**Fig. 2** Relationship between age (in weeks) and treatment success: infants aged 7 weeks and under had a higher rate of success than those aged 8 weeks and over

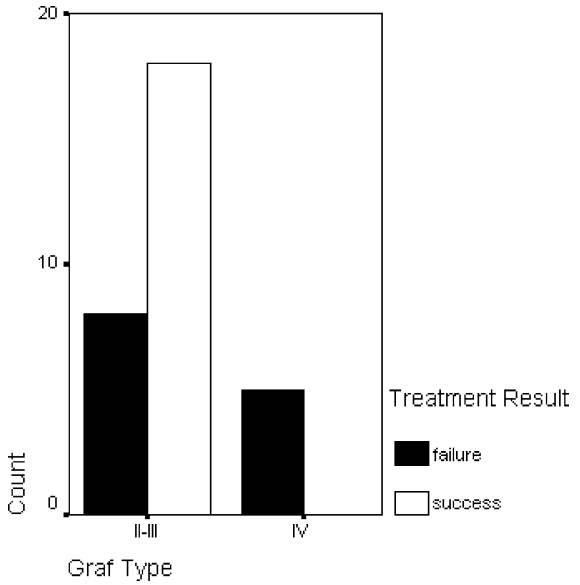


**Fig. 3** The effects of Graf type on treatment results. Infants with type IIc, IId or III hips had a higher rate of treatment success than infants with type IV hips

**Fig. 5** This pre-treatment ultrasound image of the hip in a 5-week-old infant is consistent with Graf type IV. Hip joint reduction could not be achieved after 3 weeks of Pavlik harness treatment (Patient ID 21)

## Discussion

Ultrasound-monitored Pavlik harness treatment for DDH is popular, but there is a lack of clear evidence of outcome for this treatment in the literature. Use of the Pavlik harness, with meticulous attention and ultrasound monitoring, is a safe and effective means of attempting hip reduction in DDH (Fig. 5). Through the use of the harness spontaneous repositioning, spontaneous centralisation of the femoral head, and proper anatomical and functional healing can be achieved [12]. The mechanism of reduction by means of the Pavlik harness most probably consists of a shift of the femoral head to the posterior aspect of the acetabulum, which is promoted by flexion of the hip joint. Furthermore, when an abducted position is assumed, the weight of the lower extremity plays the important role of stretching the adductor muscles and consequently allowing the dislocated femoral head to slide anteriorly over the acetabular rim and into the acetabulum. Thus, the direction of the power acting at the time of reduction is the same as that acting during manual reduction [6].

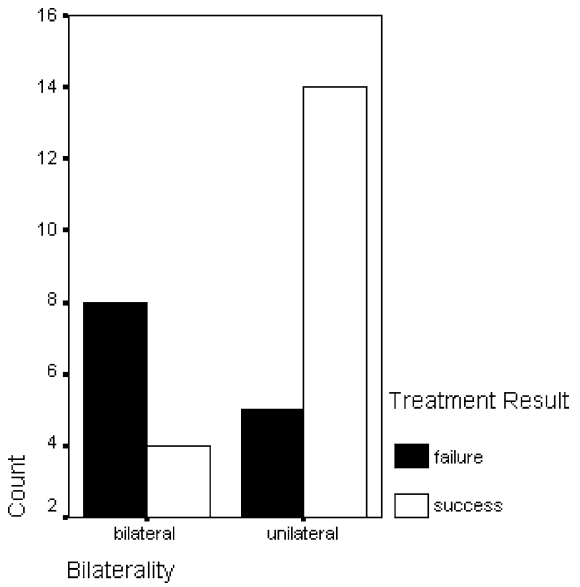


**Fig. 4** Relationship between bilaterality and treatment success: patients with bilateral DDH were found to have a lower rate of treatment success than patients who had DDH on only one side

Ultrasonography can be performed while the Pavlik harness is worn and facilitate assessment of morphology and stability, allowing monitoring during treatment. Song and Lapinski found that when imaging is used to assess hip position during treatment with a Pavlik harness, ultrasonography appears to be superior to anteroposterior radiography [15]. It should be noted that ultrasound is highly operator-dependent, and must be performed by skilled personnel.

In previous studies, it has been reported that the side of pathology and the infant's gender do not affect the result of Pavlik harness treatment [3, 9, 14]. Our findings support these findings.

The risk factors cited most often for failure of Pavlik harness treatment in DDH include bilateral dislocation [22], low $\alpha$ angle and low percentage of coverage on ultrasound [9], initial irreducibility, and advanced age at the start of treatment [3, 22]. Viere et al. [22] found an increased likelihood of failure of Pavlik harness treatment in patients with bilateral involvement, whereas Harding et al. [3] found no such increase. We found that patients who were bilaterally affected experienced failure in treatment more often.

Lerman et al. [9] reported that age at diagnosis and initiation of treatment did not correlate with failure in treating DDH with the Pavlik harness whereas, Viere et al. [22] reported that initiating Pavlik harness treatment after

the age of 7 weeks reduced the chances of success. In our study, infants aged 7 weeks or under had a higher success rate than older infants.

Lerman et al. [9] reported that Pavlik harness treatment was unsuccessful in 26 out of 137 patients. The authors concluded that irreducibility on physical examination combined with an ultrasound coverage of less than 20% defines a patient group that uniformly fails Pavlik harness treatment. Viere et al. [22] reported that the likelihood of success of Pavlik harness treatment is low for hips that cannot be reduced by the Ortolani manoeuvre in the first clinical examination. Harding et al. [3] and Harris et al. [4] concluded that it is not possible to predict by clinical examination the hips that are likely to succeed or fail with Pavlik harness treatment. Harris et al. [4] reported a 14% failure rate among Ortolani-positive hips and recorded eight initially irreducible hips that subsequently reduced in the harness. In our study group, clinical examination findings were not associated with treatment success or failure.

Uçar et al. reported a 90% success rate in treating Graf type III and IV hips with the Pavlik harness [21]. Mostert et al. reported Pavlik harness treatment to be effective in 97% of Graf type III and in 50% of Graf type IV hips, and due to the lower success rate in Graf type IV hips they recommend alternative treatment for patients with this condition [11]. Suzuki et al. [17, 18] suggested that dislocation of the femoral head reduces the success of the Pavlik harness. Suzuki et al. [18] were unable to obtain reduction with the harness in any hips in which the femoral head was completely displaced out of the socket (Suzuki type C). We were also unable to achieve reduction with the Pavlik harness in any of the five Graf type IV hips. Out of 13 Graf type III hips, we obtained seven successful results.

The success rate of Pavlik harness treatment is reported to be between 80 and 97% [2, 9, 11, 18, 21]. We achieved hip reduction with the Pavlik harness in 18 out of 31 hips. This relatively lower success rate may have been due to a combination of the small number of patients in our study and problems with family adaptation to the use of the harness.

Some hips fail to stabilise with the Pavlik harness [22]. In our series we were unable to achieve long-term stabilisation in two patients, despite the reduction that was observed in the third week of treatment (Table 1).

Wilkinson et al. reported better results with rigid splints than with the Pavlik harness in the treatment of Graf type III and IV hips [23]. These authors argue that in Graf type III and IV hips, the Pavlik harness is insufficient for the stabilisation of hip joints and for this reason rigid splints should be used [23]. Hedequist et al. report that by using an abduction brace, they obtained successful results in 13 out of 15 patients in whom Pavlik harness treatment had been unsuccessful [5].

Harding et al. [3] concluded that measurement of the $\alpha$ angle defined by Graf [1] and percentage coverage of the femoral head as described by Morin et al. [10] are not predictive of failure in Pavlik harness treatment. In contrast, Lerman et al. concluded that an initially low $\alpha$ angle correlated with an increased likelihood of eventual failure of Pavlik harness treatment [9].

In our study, none of the five patients with Graf type IV hips had success with Pavlik harness treatment. A possible explanation is that the decreased $\alpha$ angle may correlate with a higher degree of acetabular dysplasia, predisposing to instability despite the femoral head lying within the acetabulum.

Avascular necrosis rates in DDH are generally reported to be between 0 and 8% [2, 6, 14, 18]. Suzuki et al. [18] reported that avascular necrosis developed in 33.3% of 23 hips (Suzuki type B) that were treated with the Pavlik harness. It is known that a position of forced abduction is the major factor responsible for avascular necrosis in the hip joint [6]. In our study, no patients who were successfully treated with the Pavlik harness developed avascular necrosis. In administering Pavlik harness treatment, we paid close attention to the posterior strap, ensuring that it was not under tension, and we placed small pads under the infants legs to prevent excessive abduction. For the success of Pavlik harness treatment and to prevent complications, family involvement and close clinical observation are important.

In our study, one patient (ID number 6) developed a skin lesion on the medial aspect of the knee. In two patients (ID numbers 1 and 14), although reduction was obtained in the third week, hip joint stabilisation could not be achieved in the long term due to the families' lack of participation with the harness. In a third patient (ID number 3), reduction was not obtained at all, also due to a lack of family co-operation.

## Conclusion

In this study we found that treatment success was related to DDH level defined by age at the start of treatment, Graf type, and bilaterality of pathology. An age of less than 7 weeks at the start of treatment was associated with greater success, while a diagnosis of Graf type IV or bilateral disease was associated with less success.

## References


1. Graf R (1984) Classification of hip joint dysplasia by means of sonography. Arch Orthop Trauma Surg 102:248–255
2. Grill F, Bensehal H, Canadell J, Dungl P, Matasovic T, Vizkelety T (1988) The Pavlik harness in the treatment of congenital dislocating hip: report on a multicenter study of the European Paediatric Orthopaedic Society. J Pediatr Orthop 8:1–8
3. Harding MG, Harcke HT, Boven JR, Guille JT, Glutting J (1997) Management of dislocated hips with the Pavlik harness treatment and ultrasound monitoring. J Pediatr Orthop 17: 189–198
4. Harris IE, Dickens R, Menelaus MB (1992) Use of the Pavlik harness for hip displacements. When to abandon treatment. Clin Orthop 281:29–33
5. Hedequist D, Kasser J, Emans J (2003) Use of an abduction brace for developmental dysplasia of the hip after failure of Pavlik harness use. J Pediatr Orthop 23:175–177

6. Iwasaki K (1983) Treatment of congenital dislocation of the hip by the Pavlik harness. Mechanism of reduction and usage. J Bone Joint Surg Am 65:760–767
7. Jones GT, Schoenecker PL, Dias LS (1992) Developmental hip dysplasia potentiated by inappropriate use of the Pavlik harness. J Pediatr Orthop 12:722–726
8. Krismer M, Klestil T, Morscher M, Eggl H (1996) The effect of ultrasonographic screening on the incidence of developmental dislocation of the hip. Int Orthop 20:80–82
9. Lerman JA, Emans JB, Millis MB, Share J, Zurakowski D, Kasser JR (2001) Early failure of Pavlik harness treatment for developmental hip dysplasia: clinical and ultrasound predictors. J Pediatr Orthop 21:348–353
10. Morin C, Harcke HT, MacEwen GD (1985) The infant hip: real-time US assessment of acetabular development. Radiology 157:673–677
11. Mostert AK, Tulp NJ, Castelein RM (2000) Results of Pavlik harness treatment for neonatal hip dislocation as related to Graf's sonographic classification. J Pediatr Orthop 20:306–310
12. Mubarak SJ, Bialik V (2003) Pavlik. The man and his method. J Pediatr Orthop 23:342–346
13. Paton RW, Hopgood PJ, Eccles K (2004) Instability of the neonatal hip: the role of early or late splintage. Int Orthop 28:270–273
14. Ramsey PL, Lasser S, MacEwen GD (1976) Congenital dislocation of the hip. Use of the Pavlik harness in the child during the first six months of life. J Bone Joint Surg Am 58:1000–1004
15. Song KM, Lapinsky A (2000) Determination of hip position in the Pavlik harness. J Pediatr Orthop 20:317–319
16. Suzuki R (1979) Complications of the treatment of congenital dislocation of the hip by the Pavlik harness. Int Orthop 3:77–79
17. Suzuki S (1993) Ultrasound and the Pavlik harness in CDH. J Bone Joint Surg Br 75:483–487
18. Suzuki S, Kashiwagi N, Kasahara Y, Seto Y, Futami T (1996) Avascular necrosis and the Pavlik harness. The incidence of avascular necrosis in three types of congenital dislocation of the hip as classified by ultrasound. J Bone Joint Surg Br 78: 631–635
19. Szoke N, Kuhl L, Heinrichs J (1988) Ultrasound examination in the diagnosis of congenital hip dysplasia of newborns. J Pediatr Orthop 8:12–16
20. Tonnis D, Storch K, Ulbrich H (1990) Results of newborn screening for CDH with and without sonography and correlation of risk factors. J Pediatr Orthop 10:145–152
21. Uçar DH, Isiklar ZU, Kandemir U, Tumer Y (2004) Treatment of developmental dysplasia of the hip with Pavlik harness: prospective study in Graf type IIc or more severe hips. J Pediatr Orthop B 13:70–74
22. Viere RG, Birch JG, Herring JA, Roach JW, Johnston CE (1990) Use of the Pavlik harness in congenital dislocation of the hip. An analysis of failures of treatment. J Bone Joint Surg Am 72:238–244
23. Wilkinson AG, Sherlock DA, Murray GD (2002) The efficacy of the Pavlik harness, the Craig splint and the von Rosen splint in the management of neonatal dysplasia of the hip. A comparative study. J Bone Joint Surg Br 84:716–719