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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

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We have reviewed the outcome of 134 hips in 96 children with Graf type-III or type-IV dysplasia of the hip on ultrasound examination. We treated 28 affected hips in 22 children with the Craig splint, 43 hips in 30 children with the Pavlik harness, and 26 hips in 16 children with the von Rosen splint. A total of 37 affected hips in 28 children was not splinted. All children were less than three months of age at referral.

Those treated with the von Rosen splint had a significantly better ultrasound appearance at 12 to 20 weeks of age and fewer radiological abnormalities than those not splinted or treated with the Pavlik harness. In the von Rosen group no hip required further treatment with an abduction plaster or operation compared with ten in the Pavlik harness group, three in the Craig splint group and eight in the group without splintage.

Our results suggest that the von Rosen splint is more likely to improve the outcome of neonatal dysplasia of the hip and a definitive, large-scale randomised trial is therefore indicated.

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After many years of research into the detection and management of neonatal hip dysplasia there is a growing consensus that ultrasound is useful in the selection of hips which require splintage. It can detect some dysplastic hips which are missed on clinical examination[1-3] and exclude significant dysplasia in some hips which are thought to be abnormal clinically.[4] There is, however, relatively little information in the published literature on the use of ultrasound to assess the outcome and compare splinted hips with those without splintage and the effectiveness of different splints. As a result a variety of protocols for splintage is in use. In our hospital babies presenting with clinical instability of the hip may be treated by observation and no splintage or splinted using either a Pavlik harness, a Craig splint or a von Rosen splint. The management is determined by the orthopaedic consultant in charge of the patient, and this depends on which day of the week that the request for an opinion is received. Ultrasound assessment of babies with clinically suspected instability of the hip began in our hospital in 1993 and thereafter most hips were morphologically classified using the classification of Graf[5] before being seen in the orthopaedic clinic. Their progress is monitored by ultrasound. The radiologist (AGW) noted that dysplasia in babies treated with the von Rosen splint appeared to resolve more quickly than that which had other protocols of treatment. We have therefore reviewed the imaging and clinical outcome of all babies presenting with Graf type-III and type-IV dysplasia in order to assess the effectiveness of the different protocols of management.

Patients and Methods

The ultrasound reports of all babies who were imaged for clinically suspected neonatal dysplasia of the hip between 1993 and 1998 were reviewed and those classified as Graf type III or type IV formed the basis of the study. Babies had been referred because of clinically suspected instability or the presence of risk factors for hip dysplasia. The scans were reassessed and those in which the quality of the image was inadequate (incorrect plane of imaging), or were not unequivocally Graf type III or type IV, were excluded from the study. Babies who were first imaged over the age of three months and those with a neurological abnormality were also excluded. A total of 134 hips in 96 babies (84 girls and 12 boys) was included in the study.

The imaging was reviewed with particular attention to the first ultrasound examination, that carried out at 12 to 20

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weeks of age, and radiographs taken at six to 12 months of age. For the purpose of this study the Graf types were given a numerical value as shown in Table I. Changes in ultrasound grading between the first ultrasound and that at 12 to 20 weeks could then be calculated numerically with negative values representing improvement in ultrasound appearance and positive values deterioration.

The radiographs were assessed independently by the radiologist and the orthopaedic surgeon (DAS). The former assessed the films non-quantitatively, grading them as A (normal), B (mildly dysplastic, when only the lateral acetabular margin was abnormal), C (moderately dysplastic, when the whole of the acetabular roof was abnormal), D (severely dysplastic, when there was displacement of the femoral head) or E (dislocated). The surgeon assessed the films quantitatively measuring the acetabular angle and c/b ratio where 'c' is the distance from the centre line to the most medial area of the proximal femoral metaphysis and 'b' is the distance to the edge of the acetabulum.[6] A higher ratio indicates more severe dysplasia. Both assessors were unaware of the ultrasound results when assessing the radiographs although these had been available for clinical management and therefore there was no formal blinding. The clinical notes were then reviewed and details of splintage and further management such as an abduction plaster and operative procedures recorded.

The babies were divided into four groups depending upon management: unsplinted or treatment in either the Pavlik harness, Craig splint or von Rosen splint. Table II shows the numbers of hips of each Graf classification in the treatment groups and the age at which the splints were applied.

For statistical analysis we used the chi-squared test and the Kruskal-Wallis test.

Table I. The numerical values given to the Graf type

Graf type	Numerical value
I	1
IIa	2
IIb	3
IIc	4
III	5
IV	6

Results

Changes in the numerical value of the ultrasound grading between the first ultrasound and that undertaken at 12 to 20 weeks are shown in Table II. There is a difference between the methods of treatment with the van Rosen splint being the best both if the second ultrasound is taken in isolation as an ordered outcome (chi-squared test 9.91, 3df, $p = 0.019$) and when considering improvement between the first and second ultrasound (chi-squared test 10.58, 3df, $p = 0.014$).

The results of the assessment of the pelvic radiographs between six and 12 months are also shown in Table II. Statistical analysis using the Kruskal-Wallis test showed no difference between the splints for the c/b ratio (chi-squared test, 0.32, 3df, $p = 0.96$) on follow-up films whereas there was a weak difference (chi-squared test 5.76, 3df, $p = 0.12$) for the acetabular angle with no splint being worst and the von Rosen being best. Statistical analysis of the radiologist's grading is contradictory. Taking the groupings A and B, *versus* C, D and E, there is evidence of a difference (chi-squared test 10.92, 3df, $p = 0.012$), but taking the assessment as an ordered outcome showed no difference (chi-squared test 3.39, 3df, $p = 0.33$). There was no sign of avascular necrosis or deformity of the femoral head because of splintage in any patient.

The number of hips requiring an abduction plaster and/or an operative procedure for failure of the initial treatment is shown in Table II.

Discussion

The management of neonatal instability of the hip is contentious. There is debate on several issues including the role of clinical and ultrasound assessment, the preference of

Table II. The Graf type of the neonatal dysplastic hips, the age of the babies when the splints were first applied and the clinical outcomes according to the type of treatment

	Splint			
	Craig	**Pavlik**	**von Rosen**	**No splint**
Graf type (number of hips)				
III	28	40	24	37
IV	0	3	2	0
Mean age at which splint applied in days (range)	37 (6 to 122)	49 (7 to 129)	26 (4 to 71)	
Mean (±SD) improvement on ultrasound*	-1.96 ± 1.17	-1.62 ± 1.41	-2.74 ± 0.96	-2.1 ± 1.40
Assessment of radiograph				
Number (%) with acetabular angle ≥28°	8 (*29*)	14 (*33*)	2 (*9*)†	13 (*38*)‡
Number (%) with c/b ratio >0.75	16 (*57*)	21 (*49*)	14 (*61*)†	18 (*53*)‡
Number (%) moderately dysplastic or worse	4 (*14*)	14 (*33*)	0 (*0*)†	6 (*18*)‡
Number of hips requiring further treatment				
Plaster	3	10	0	8
Operation	1	3	0	2

*between first examination and at 12 to 20 weeks. Negative value indicates improvement
† n = 23
‡ n = 34

morphological[5] or dynamic[7] ultrasound tests, the degree of dysplasia which requires treatment and the type of splint to be used. Studies on the effectiveness of treatment are also complicated by the large number of dysplastic hips which show spontaneous improvement.[1,2,8]

Pelvic radiographs are widely used to determine the degree of residual hip dysplasia, but simple quantitative outcome measures such as the acetabular index, are subject to wide intra- and interobserver variation.[9,10] The centre-edge angle of Wiberg is difficult to measure in the younger child because of insufficient development of the femoral head.[11] The c/b ratio should overcome some of these difficulties, but published data do not include children under two years of age.[6] We examined the c/b ratio and the acetabular index and also used an objective grading which was not quantitative. Of the quantitative parameters, only the acetabular angle showed a weak relationship to the splint which was used whereas the objective radiological grading showed a difference similar to that found on ultrasound grading. The acetabular angle and objective grading thus have some validity and are simple to record.

In our hospital, a variety of protocols of management was in use between 1993 and 1998, including three types of abduction splint. This allowed a comparison of the efficacy of the splints. An earlier report suggested that use of the von Rosen splint resulted in more rapid return of the ultrasound appearance to normal.[12] Our study has more patients, a longer follow-up and data on secondary treatment with abduction plasters and operative procedures and on the radiological appearance. Babies treated with the von Rosen splint showed significantly greater improvement in ultrasound grading between that at the onset of splintage and that at 12 to 20 weeks of age, confirming our earlier report. None of those treated with a von Rosen splint required further treatment, unlike those treated by any of the other options.

There are few published data comparing the efficacy of different splints in neonatal hip dysplasia and none in which the outcome for different treatments has been assessed by ultrasound and radiography. Hinderaker, Rygh and Uden[13] compared the use of the Frejka pillow with the von Rosen splint. Four of 101 children treated with the Frejka pillow required further treatment for residual acetabular dysplasia compared with none of 307 children treated with the von Rosen splint.

Other studies have shown the von Rosen splint to be effective,[14-16] but the use of the Pavlik harness has become more widespread in recent years. There is no previous published comparison of the von Rosen splint and the Pavlik harness.

The Pavlik harness has been reported to be effective in 97% of Graf type-III and 50% of type-IV hips.[17] This may be because of difficulty in maintaining the position of the femoral head in a very dysplastic acetabulum using the Pavlik harness. It is possible that a more rigid splint would be more suitable. The use of the Pavlik harness in stable dysplastic hips has been shown to improve the acetabular cover as measured by ultrasound in the first three months compared with that in unsplinted control hips, although there was no significant difference in the measurements of the acetabular angle on plain radiographs at three or 24 months.[18] These findings are similar to those in our study in that the effect of splintage on the ultrasound appearance is more pronounced than that in later radiographs. In our study, in which all hips had ultrasonographic evidence of some degree of subluxation or dislocation, patients without splintage showed a greater improvement in the ultrasound appearance than those treated with the Pavlik harness. This would support the theory that a non-rigid splint cannot maintain the femoral head in the centre of a very dysplastic acetabulum, whereas it may be effective in less degrees of dysplasia.

The current popularity of the Pavlik harness may be related to fears of avascular necrosis associated with the von Rosen splint. Avascular necrosis has been reported in 1% of hips treated with the von Rosen splint[17] but a rate of 5.4% has been reported in children treated with the Pavlik harness.[19] A comparative study of complications caused by the use of the von Rosen splint and Pavlik harness showed avascular necrosis in 2% of patients treated with the von Rosen splint and in 13% of those treated with the Pavlik harness.[20] It is likely that many factors, including the age of application and degree of abduction, affect the rate of avascular necrosis.[16,21] For instance, in the comparative series reported by Bradley et al[20] babies under the age of six weeks were treated primarily with the von Rosen splint and older babies with the Pavlik harness; the different rates of avascular necrosis in these groups may be explained by age as well as the type of splint. Pressure deformity of the femoral head caused by the von Rosen splint has been reported, although this decreases with age and is avoided when adequate mobility within the splint is allowed.[22] von Rosen's original description of the splint emphasises that excessive abduction should be avoided.[23] We found no evidence of avascular necrosis or deformity of the femoral head in any of our patients, which is consistent with the low incidence described in their reports.

Any study which examines the efficacy of splints for neonatal hip dysplasia must take account of the natural tendency of hips without splintage to improve with time. In our study, these hips showed greater improvement on ultrasound than those treated with the Pavlik harness or the Craig splint but less than those treated with the von Rosen splint.

If we had not included patients without splintage as a control group a spurious benefit from the Pavlik harness and the Craig splint may have been concluded. Other studies have shown that many dysplastic hips improve without treatment particularly if they are stable.[1,2,8,18] It is important when comparing studies to ensure that similar groups of patients are included. This is particularly difficult when different ultrasound classifications are used, for example the Graf classification[5] or a classification based on the degree of cover of the femoral head.[19]

The age at which the splint is first applied may have an influence on the efficacy of treatment. In our study the von Rosen splints were applied earlier, and this may have contributed to the greater efficacy of this splint compared with the Craig splint or Pavlik harness.

Our study is the first to compare the efficacy of the Pavlik harness with the von Rosen splint, but is compromised by being retrospective with small numbers and lack of randomisation and relatively short follow-up. It raises significant concerns about the efficacy of the Pavlik harness compared with the von Rosen splint and suggests that a large-scale prospective, randomised trial of these two splints with long-term follow-up is required.

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