Cost-effectiveness of universal ultrasound screening compared with clinical examination alone in the diagnosis and treatment of neonatal hip dysplasia in Austria

Between 1978 and 1997 all newborns in the Austrian province of Tyrol were reviewed regarding hip dysplasia and related surgery. This involved a mean of 8257 births per year (7766 to 8858). Two observation periods were determined: 1978 to 1982 (clinical examination alone) and 1993 to 1997 (clinical examination and universal ultrasound screening). A retrospective analysis compared the number and cost of interventions due to hip dysplasia in three patient age groups: A, 0 to < 1.5 years; B, ≥ 1.5 to < 15 years; and C, ≥ 15 to < 35 years.

In group A, there was a decrease in hip reductions from a mean of 25.2 (SD 2.8) to 7.0 (SD 1.4) cases per year. In group B, operative procedures decreased from a mean of 17.8 (SD 3.5) to 2.6 (SD 1.3) per year. There was a 75.9% decrease in the total number of interventions for groups A and B.

An increase of €57 000 in the overall cost per year for the second period (1993 to 1997) was seen, mainly due to the screening programme. However, there was a marked reduction in costs of all surgical and non-surgical treatments for dysplastic hips from €410 000 (1978 to 1982) to €117 000 (1993 to 1997). We believe the small proportional increase in costs of the universal ultrasound screening programme is justifiable as it was associated with a reduction in the number of non-surgical and surgical interventions. We therefore recommend universal hip ultrasound screening for neonates.
added. After discharge, all infants with abnormal clinical signs or risk factors of positive family history or breech birth were re-examined at the age of six to eight weeks and an x-ray taken if clinically suspicious and, if necessary, infants were treated in our hospital. Those infants with unremarkable findings at this time were followed up by an orthopaedic surgeon for a further period of between six and eight weeks.

A nationwide ultrasound screening programme was developed between 1983 and 1988. Since then, ultrasound screening using the Graf method combined with clinical examination is part of a National Health Programme plan (NHP) for newborns and babies. All are screened within a week of birth by a trained paediatric orthopaedic surgeon. After discharge, all infants with unremarkable hips are routinely followed up by an orthopaedic surgeon for six to eight weeks as part of the NHP plan, while those with abnormal clinical or sonographic findings or risk factors (positive family history, breech birth) are also reviewed clinically at the age of six to eight weeks, and undergo further sonographic evaluation of the hips.

For the study, two observation periods were determined. Period I (clinical examination alone) was between 1 January 1978 and 31 December 1982. Period II (universal ultrasound and clinical examination) was between 1 January 1993 and 31 December 1997. In period I, 41 163 infants (21 176 males, 19 987 females) were included, compared with 41 853 (21 469 males, 20 384 females) in period II.

The period between 1983 and 1993 was excluded to minimise bias due to the learning experience associated with the introduction of the ultrasound screening programme. A retrospective analysis of the two periods was performed regarding surgical treatment and costs. During the overall observation period the indications for surgery did not change. However, new operations such as the periacetabular osteotomy were introduced. For all patients, the treatment protocol recommended by Graf was used.

Patients with hip dysplasia secondary to conditions such as neuromuscular disorders or Perthes’ disease were excluded. According to age-dependent treatment principles, three patient samples were determined encompassing the following age ranges: group A, 0 to < 1.5 years; group B, ≥ 1.5 to < 15 years; and group C, ≥ 15 to < 35 years of age.

The annual birth rate in the province was recorded, as published by Statistics Austria. From the hospital database we obtained the number of clinical follow-up examinations per child, the number of open and closed reductions, the number and type of operation per child and group of children and number of splinting devices used.

The costs of hospital admissions for closed reductions and open operations were calculated on the basis of the procedures undertaken, duration of hospital stay and specialty-specific costs per in-patient day. It was calculated that a single closed reduction cost €3000, which included the operating theatre occupancy, anaesthesia, theatre staff, and number and type of staff involved during casting, and clinical and radiological follow-up. In a similar way it was calculated that the mean cost of a single operation, such as varus derotation or pelvic osteotomy, was €12 000. Arthroplasty of the hip was not included. The costs of hospital in-patient admissions were based on national reference costs for surgical procedures, clinical and radiological follow-ups and hospital-specific costs per in-patient day.

The mean costs for outpatient consultations were assumed to be €500 per child for both observation periods, including staff in attendance, clinical follow-up examinations and radiological follow-ups.

The overall cost of ultrasound examination in hospital was €180 000. This was derived from the time and personnel per investigation and cost of equipment. The overall cost of ultrasonographic examinations by orthopaedic surgeons at outpatient visits was €170 000. This was calculated according to reimbursements from the national health insurance.

The data were processed using the Statistical Package for Social Sciences v.13 (SPSS Inc., Chicago, Illinois).

Results
From 1978 to 1997 there were 165 134 live births representing a mean of 8257 per year (7766 to 8858). According to the Austrian Ministry of Health, 96% of all newborns were included during both study periods. With the introduction of ultrasound hip screening, the rate of splintage dropped from a mean of 170 cases per year (147 to 190) in period I to a mean of 90 per year (82 to 105) in period II. When comparing the age at which treatment was instigated between the two periods, there was a decrease in hip reductions from a mean of 25.2 (SD 2.8) cases per year in period I to a mean of 7.0 (SD 1.4) in period II in group A. In group B, there was a decrease in surgical procedures for dysplastic hips from a mean of 17.8 (SD 3.5) to a mean of 2.6 (SD 1.3) per year for periods I and II, respectively. A slight reduction in the number of operations for dysplastic hips was seen in the oldest patients of group C (Fig. 1). In period I, a total of 105 pelvic osteotomies and varus derotation osteotomies were performed, compared with 76 operations for the same indications in period II. Since the introduction of universal hip ultrasound screening, the decrease in the number of interventions for groups A and B (combined age range 0 to < 15 years) was 75.9% (Table I). The comparison of costs between the periods showed an overall increase in the costs of screening and treatment for DDH of €57 000 per year between 1993 and 1998, which was mainly due to...
the ultrasound programme (Table II). However, there was a considerable cost reduction regarding operative and non-operative treatment for dysplastic hips from €410 000 (1978 to 1982) to €117 000 (1993 to 1997).

**Table I.** Comparison of total number of surgical interventions between the two observation periods (VDRO, varus derotation osteotomy)

<table>
<thead>
<tr>
<th>Age group</th>
<th>1978 to 1982</th>
<th>1993 to 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (0 to &lt; 1.5 years)</td>
<td>Closed reductions 126</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Open reductions 14</td>
<td>7</td>
</tr>
<tr>
<td>B (≥ 1.5 to &lt; 15 years)</td>
<td>Acetabular osteotomies/VDROs 89</td>
<td>13</td>
</tr>
<tr>
<td>C (≥ 15 to &lt; 35 years)</td>
<td>Acetabular osteotomies/VDROs 105</td>
<td>76</td>
</tr>
</tbody>
</table>

**Table II.** Comparison of mean costs in Euros between the study periods

<table>
<thead>
<tr>
<th>Service</th>
<th>1978 to 1982 Cost (Euros per year)</th>
<th>1993 to 1997 Cost (Euros per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavlik harness</td>
<td>40 000</td>
<td>Tuebinger bandage</td>
</tr>
<tr>
<td>Clinical follow-up</td>
<td>85 000</td>
<td>Clinical follow-up examinations</td>
</tr>
<tr>
<td>examinations</td>
<td></td>
<td>Closed reduction</td>
</tr>
<tr>
<td>Closed reduction</td>
<td>69 000</td>
<td>Surgery</td>
</tr>
<tr>
<td>Surgery</td>
<td>216 000</td>
<td>Ultrasound screening</td>
</tr>
<tr>
<td>Total costs of interventions</td>
<td>410 000</td>
<td></td>
</tr>
<tr>
<td>Total costs</td>
<td>41 000</td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The economic evaluation of treatment regimes is of increasing importance in times of escalating healthcare budgets. It is proposed that early diagnosis of DDH allows...
comparably cheap treatment with a simple brace\textsuperscript{18,29} and that delayed diagnosis carries a greater risk for surgical treatment at a later stage.\textsuperscript{17,30,31} It is reported that 15\% of all infants have more than one risk factor for DDH\textsuperscript{14} and risk factors are seen in 40\% of newborns with a clinically detectable abnormality of the hip.\textsuperscript{11,32} Previous studies have shown a low incidence of late-detected hip dysplasia after ultrasound screening of newborns. In a group of 14 050 infants, Clegg and al-Chalabi\textsuperscript{35} found no case and Rosendahl, Markestad and Lie\textsuperscript{34} reported one case of late detection in a selective ultrasound screening group, two in a group screened only clinically, but no cases in a universal ultrasound screening group. When evaluating the cost-effectiveness of hip ultrasound screening, Gray et al\textsuperscript{31} showed significantly lower costs of splinting and lower costs to the family associated with surgery compared with the clinical examination group.

The advantages of ultrasound screening are direct observation and dynamic assessment in the evaluation of the newborn hip. However, knowledge and practice are needed to obtain reliable results and false-positive results lead to overtreatment.\textsuperscript{10,34-36} In our study, the splintage rate controversially dropped with the introduction of hip ultrasound whereas clinical examination alone was associated with a higher treatment rate. The mean decrease in hip reductions was due to successful primary splintage in cases of sonographically detected abnormal hips. In a prospective randomised trial, after a follow-up of six to 11 years, Holen et al\textsuperscript{14} found no statistically significant difference for late-detected hip dysplasia between children receiving ultrasound screening (n = 1) and those having clinical examination alone (n = 5). Consequently, they considered universal ultrasound screening unnecessary, but recommended selective ultrasound screening for neonates with abnormal or suspicious clinical findings and those with risk factors for hip dysplasia. These authors presented data only for late-detected hip dysplasia and no intermediate findings, such as the number of additional clinical follow-ups or the number of splinting devices, were described. Furthermore, they used the ultrasound screening method as described by Terjesen et al\textsuperscript{5} and Holen et al,\textsuperscript{37} whereas recent studies have shown better intra-observer reliability for the Graf method,\textsuperscript{38} which is strictly standardised,\textsuperscript{39} but requires teaching and experience to avoid misdiagnosis.\textsuperscript{31} The results in other studies might have been influenced because patients were included during the learning period.\textsuperscript{14}

The best timing for hip ultrasound screening is debatable. Graf\textsuperscript{39} recommends early screening to allow treatment during the peak growth of the acetabulum, which has a high potential of remodelling as form follows function. Conversely, early screening leads to more false positive results.\textsuperscript{14} Hence, Grill and Müller\textsuperscript{19} recommend the sixth to eighth week as the optimal time, which was implemented in the Austrian screening programme.

According to the Austrian Ministry of Health, 96\% of newborn babies are screened. This high rate is due to a pregnancy and early-childhood medical record book. Several investigations, including hip sonography, are compulsory and predetermined in the pregnancy and early-childhood medical record book and linked to a federal premium. The province of Tyrol has a mixed urban-rural population with one major city with over 100 000 inhabitants in the centre. There are ultrasound facilities for hip screening of the newborn in each of the eight district hospitals in the county. Ultrasound screening at the age of six to eight weeks is performed by every orthopaedic surgeon in private practice in the county. A recent report\textsuperscript{20} demonstrated that newborns screened with ultrasonography incurred significantly higher costs over the first two years compared with those who underwent clinical screening alone. The total hospital costs were lower for the infants screened with ultrasound, but the difference was not especially marked. The study also showed that ultrasound screening reduced the splintage rates, but was not associated with abnormal hip development or higher rates of surgical treatment by two years of age.\textsuperscript{20}

Differences between healthcare systems, with regard to their financing, management, clinical practice and costs, limit direct comparison among different countries without appropriate adjustments. However, our results should be of interest in countries without a universal hip screening programme. This study shows higher initial costs caused by the ultrasound screening, but also a significant reduction in the total number and overall costs of dysplastic hips undergoing operative and non-operative treatment. Similar findings were reported by Clegg et al,\textsuperscript{22} who compared the surgical costs of three screening methods for DDH: universal clinical examination alone, universal clinical examination with selective ultrasound examination for newborn babies with risk factors, and universal ultrasound screening. The mean costs per 1000 live births were £5110 for clinical investigation alone, £3811 for selective ultrasound screening, and £468 for universal ultrasound screening. With the addition of the costs of surgical treatment, the overall costs were comparable among the different methods.

In our view ultrasonographic evaluation reduces uncertainty and may reduce further costs to health services and affected families. Alongside this, important non-financial aspects, such as psychological factors, should be considered.

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\textbf{References}


