Detection and treatment of developmental dysplasia of the hip in infants: updates and recommendations

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Purpose of review
Developmental dysplasia of the hip (DDH) is common and is a source of potentially avoidable morbidity through childhood and adult life. Despite progress over the past century, there is a wide variation in policy, practice and outcomes between countries. This review considers information from a geographically wide range of locations to evaluate the impact of these variations and understand how these variations arise. The aim is to help clinicians and policymakers adopt the best practices for their population.

Recent findings
There is a lack of randomized controlled trials to guide decisions on screening. Given the large numbers to treat and preexisting practices, it is unlikely that such trials of sufficient statistical power will be performed. However, many whole population studies are becoming available from different countries that allow an assessment and comparison of the impact of their strategies.

Summary
Standardizing metrics in studies and defining late diagnosis would improve comparisons across studies. The general trend appears to favour universal screening to reduce the risk of late diagnosis, the need for surgery and the subsequent poorer outcomes. Notably, resource-constrained countries like Mongolia have successfully implemented universal screening, showing that effective strategies can be adopted regardless of resources.

Keywords
developmental dysplasia of the hip, hip dysplasia treatment, hip ultrasound screening

INTRODUCTION

Over a century ago, in 1912, Pierre Le Demany [1] demonstrated how to detect and treat unstable hips in infants effectively. He described both what were to become known as Ortolani's and Barlow's tests and described a simple splint, foretelling the modern approach to managing hip instability. But his research did not gain broad recognition, perhaps impacted by subsequent wartime loss of international contacts. Despite the subsequent advances in imaging, the best care remains debated, and limping toddlers still present with dislocated hips requiring surgery with potentially poor outcomes.

EVOLUTION OF TREATMENT

Early studies may lack rigor in comparison to recent research but remain relevant. Putti [2] demonstrated that early bracing of infants' dislocated hips gave positive outcomes, potentially avoiding surgery. His student, Marino Ortolani [3], in 1937 published his clinical sign during hip examination in relaxed infants, the palpable and visible response he termed in Italian as sbalzo (surge), scossa (shock) and scatto (click), which English translations have simplified to 'click,' leading to some confusion. He emphasized the importance of early detection and intervention.

Pavlik [4], a student of Frejka in Brno, was troubled by the high rate of avascular necrosis (AVN) of the femoral head with rigid splints. Consequently, he developed his own soft, fabric splint to dynamically centre the hips by encouraging flexion

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KEY POINTS

- Treatment of hip dislocation in the neonatal period is in most cases successful with simple splintage.
- Although neonatal clinical screening has been very effective in some locations, it has been hard to replicate generally.
- Clinical examination has been shown to have poor repeatability and reliability when compared to ultrasonic findings.
- Services should monitor performance, such as late diagnosis rates, to ensure the most appropriate policies are in place to avoid the burden of avoidable pathology.
- Swaddling of infants should be discouraged to avoid interfering with normal hip development.

and abduction. He achieved a high success rate and low AVN complication rates.

Barlow [5] in 1962 detailed his application of Ortolani's test on newborn hips, along with his own test for detecting instability. He created a splint, similar to Pavlik's, for treating unstable hips, noting rapid stabilization within days suggesting the potential for natural recovery. He observed that stable hips at two months of age were radiographically normal at one year. He experimented by deferring treatment until the age of 2 months but found that two out of the 15 hips had worsened without early intervention and subsequently failed to respond to conservative treatment. Consequently, he recommended immediate treatment of hip instability upon diagnosis, ideally within the first week of life. However, this small sample is frequently recounted by others as a rational for deferring treatment.

From 1948, Von Rosen implemented neonatal, clinical screening and early treatment in Malmo, achieving nearly unmatched results with a late diagnosis rate of only 0.16 per thousand live births with his definition of a 'late diagnosis' as being after 1 week of age [6]. Despite criticisms for possibly over-treating, the Malmo approach was demonstrated by Fredensborg [7] as well tolerated for infants.

Ultrasound imaging enhanced understanding of infant hip anatomy. Graf's method [8] assesses and quantifies acetabular morphology, while Harcke's evaluates femoral head position and stability with biplanar imaging. The introduction of ultrasound clarified the spectrum of pathology from dislocation through instability and simple dysplasia to normal. Baronciani [9] correlated clinical findings against ultrasound findings as the gold standard and found that although the Barlow/Ortolani manoeuvres showed good specificity, the sensitivity was poor, and with the large number of infants, the positive predictive value was only 0.35. Hip dysplasia assessment is complicated by the changes of normative ultrasonic morphology with maturation [10], but ultrasound has improved detection rates [11].

CURRENT STATUS

As ultrasound became more accessible, approaches to screening diversified. Some services integrated selective ultrasound screening for cases with abnormal examination and high-risk individuals. In other regions, a policy of universal ultrasound screening for all infants emerged. Assessing the effectiveness of these different approaches is challenging due to the variation in policy, execution and reporting, which hinders direct comparison [12].

The effectiveness of a policy can be assessed by incidence of late presentation requiring surgical intervention (open and closed reductions), and the overall treatment rates in a population. Measuring other outcomes, such as bracing or pelvic osteotomies, can be difficult as indications can be subjective. It is recognized that a high proportion of young adults requiring arthroplasty have previously untreated dysplasia. The influence of DDH management on adult hip degeneration [13] may emerge over time, with joint registries providing prospectively collected long-term data. A large population study in China [14] reported an incidence of DDH of 2.77% in young women many of whom had not been previously diagnosed.

Holen *et al*. [15] published one of the few randomized trials comparing selective with universal ultrasound screening. They found that universal ultrasound did not significantly reduce late dislocations compared to selective screening. However, the power of this study was limited by their high detection rate with clinical examination alone. He suggested universal ultrasound might not be necessary if effective clinical screening was already in place. A Cochrane review and meta-analysis [16] was inconclusive, but was limited by the paucity of qualifying studies to compare ultrasonic screening versus clinical surveillance.

Kuitunen *et al*. [17▪] 2022 analysis of 76 studies involving over 16 million births investigated early detection, treatment, and operative incidence. They categorized the studies into clinical, selective ultrasound, and universal ultrasound screenings. While results varied, possibly due to differences in execution, reporting methods, and data completeness, they found that universal screening correlated with a higher rate of nonoperative treatment.

Selective screening in Sweden yielded impressive outcomes, with a late presentation rate (diagnosis after 14 days) of only 0.12 per 1000 live births between 2000 and 2009 [18]. Japan reported a late diagnosis rate of 0.09/1000 late diagnosis (>1 year) with selective screening [19]. New Zealand reported a late presentation rate (>1 year) of 0.29 per 1000 [20], while Manitoba had poorer results, possibly due to the lack of a formal surveillance program in a region with a dispersed population and a high prevalence of DDH [21]. Both Düppe and Danielsson [6] and MacNicol [22] highlighted the advantage of having a small number of experienced examiners conduct neonatal clinical screening.

Despite having largely similar policies of selective screening across the United Kingdom, very different results have been published. In Great Britain, Broadhurst *et al*. [23] showed a late diagnosis rate (>1 year of age) of DDH of 1.28 per 1000 live births. This was derived from national database analysis across varied practice regions. In contrast, Northern Ireland's prospective data revealed a lower rate of 0.3 per 1000 [24]. Other UK studies [25] report relatively high rates of delayed diagnosis of DDH. The poor effectiveness of clinical surveillance in the UK was questioned by an Australian study [26], as they achieved a late diagnosis rate of just 0.19/1000 presenting after 3 months of age when using similar protocols.

Despite having a similar policy to the UK involving universal clinical screening and 6-week ultrasound scans for at-risk infants, the French data indicate a late (>1 year) diagnosis rate of 0.08/1000 live births [27].

In 1992, Austria adopted universal hip ultrasound screening with scans after birth and a six-week follow-up scan. Tschauner *et al*. [28] found that the age at treatment reduced from 5.5 to 2 months after and the success rate of closed reduction increased from 88.7 to 98.9%, the need for surgical open reduction fell by a factor of 10. The AVN rate also reduced, eliminating the incidence of severe (Tönnis grade 2) AVN completely. Since the introduction, Austrian ministry of health data [29] demonstrated a low incidence of open reduction surgery (0.16/1000) and a reduction of pelvic surgery by 46%. Biedermann *et al*. [30] found even lower rates of open reduction (0.04/1000) in the west of Austria, although the closed reduction rate was higher (0.86/1000). Impressively, no late-presenting cases were observed among the screened population.

In the USA, the US preventive services task force [31] in 2006 stated that most abnormal hips identified by newborn clinical examination usually resolve on their own, and the evidence was insufficient to support screening. A decision was made not to review the evidence or re-issue recommendations. The American Academy of Pediatrics (2016) [32] and the American Academy of Orthopaedics Surgeons (AAOS 2022) [33▪] recommend selective screening based on repeated examination and risk factors. Data on normal ultrasound maturation appear to have been interpreted as spontaneous resolution. The AAOS suggests that evidence is lacking to support ultrasound-based treatment despite the well documented poor sensitivity and specificity of clinical examination alone. There is a lack of current information on late hip dislocation incidence in the USA. However, a study in 2017 [34] found 2.2% of infants had hip ultrasounds, compared to 26% in Northern Ireland [24] despite similar policies of selective screening being in place.

TIMING OF TREATMENT

Rosendahl *et al*. [35] conducted a trial comparing immediate splintage to sonographic monitoring for neonatal dysplastic, but stable hips. All dysplastic hips in treatment improved and about half of the monitored hips progressed without treatment the other half requiring splintage. Similar outcomes were seen in both groups at the 1-year follow-up.

Early splintage is crucial for dislocated hips, with a 4% failure rate using Pavlik harness within 2 weeks of birth, rising to 21% for infants 2–8 weeks old [36]. Harding *et al*. [37] found a 36% failure rate in those treated before 3 weeks versus 79% for older infants. De Pellegrin *et al*. [38] recommend starting treatment within 6 weeks to ensure normal acetabular development. Atalar *et al*. [39] reported a significantly higher failure rate after 7 weeks. Ömeroglu [40] advised against Pavlik harness use for dislocated hips after 3 months. Prompt ultrasound assessment is therefore necessary if neonatal clinical instability is detected. A contrary view was taken by Larson *et al*. [41], who found similar failure rates for infants with treatment initiation before and after 30 days of age. They cited concerns that maternal bonding may be affected by use of a harness; however, a recent study is very reassuring in this matter [42].

Critics of universal screening argue that it leads to increased treatment and potential complications, notably AVN. This is identified through radiographic changes in the proximal femur posttreatment; AVN ranges from mild transient alterations in radiographic bony texture to severe growth disruption of the femoral head that may not be evident until later in childhood.

Studies show that AVN is unlikely in dysplastic hips but more prevalent in older infants with decentred hips [43]. Preultrasound era studies indicated higher AVN rates in older infants with clinically

evident dislocations [44]. Between 2011 and 2017, in Northern Ireland [24], only two out of 2027 hips treated with a Pavlik harness developed AVN. These both occurred in infants over 3 months old with decentred hips. Hussain *et al*. [45] reported that all cases of AVN occurred in patients who underwent surgery, with none observed in patients who were treated with splinting alone. Splintage poses a minimal AVN risk compared to closed or open reduction procedures [46–48]. While rare, femoral nerve palsy can occur with Pavlik Harness treatment, symptoms typically resolve quickly once the harness is removed and harness use can be resumed after nerve recovery [24,49].

Screening programs will likely raise treatment rates in younger infants with dysplasia while decreasing treatment rate and the necessity for open surgery in older infants, ultimately lowering the overall risk of complications and reducing the incidence of residual dysplasia in the population.

PERFORMANCE MONITORING

A thorough performance monitoring system is essential. Which key metrics should we track? Standardizing these metrics would enable easier comparison across studies. Essential measures should encompass treatment rate, late diagnosis rate at certain time-points, for example, post 1-year, clear categorization between dislocation and dysplasia. Data on surgical rates, types of procedures such as open or closed reductions, and corrective osteotomies are crucial.

Clinical surveillance has been successful in some regions. However, it cannot detect all cases of dysplasia. Published results vary greatly, probably reflecting differences in delivery systems and practitioner skills. This highlights the need for quality control and attention to training and human factors.

If diagnosis is made at walking age, the hip will generally require an open reduction. Therefore, children who undergo closed reductions of the hips have usually been referred at a young age because of abnormal findings. In Northern Ireland [24] by addressing these delays, the closed reduction rate was decreased by 75%, to 0.27 per 1000 live births. We suggest that the closed reduction rate might be a useful indicator of effectiveness of a screening system. Having target times for referrals can offer real-time feedback on performance.

Current research underscores the importance of ongoing attentiveness and careful assessment of infants' hips in order to spot any signs of instability early. Doing so ensures that those in need of prompt splinting are quickly identified, leading to efficient, structured processes for their further examination and treatment. The British Society for Children's Orthopaedic Surgery's consensus statement [50] from 2022 advises that babies showing any clinical instability at birth should undergo ultrasound imaging and receive professional evaluation within a 2-week period. The International Consensus Committee for DDH Evaluation (ICODE) have gone further and recommend universal screening [51]. The use of radiographs as a first-line screening method is inappropriate, as by the time an infant is mature enough to interpret the x-ray reliably, the opportunity for early treatment has likely passed.

POLICY

Policy decisions must consider the economic cost-benefit, including the still uncertain long-term impact of late diagnosed dysplasia on adult hip pathology, as well as the costs associated with medicolegal actions.

Clegg *et al*. [52] presented data to show universal screening to be largely cost neutral to services with the cost of screening largely offset by savings on surgical intervention. Several affluent European nations have followed Austria's example by implementing widespread ultrasound screening. Mongolia [53], despite being a nation with limited economic resources, but with a high prevalence of hip pathology, has successfully established universal screening since 2017. This has been a product of a Swiss-Mongolian initiative. As a part of their work, they have also confirmed how swaddling young infants and restricting hip movement has a significant adverse impact on the normal development and maturation of hips [54].

CONCLUSION

There are no high-quality controlled clinical trials to guide the choice between universal ultrasound or selective ultrasound screening for DDH. They are now unlikely to be conducted due to practical and ethical issues. Such a study would also face the challenge of achieving an unbiased randomisation that has been problematic in other screening scenarios [55]. However, the difference in policies between nations is now yielding valuable insights.

Despite relying on the same pool of published literature, different conclusions have been reached by policy makers. On reading the analyses, it is evident that different literature sources have been drawn upon to support conclusions. We need to be wary of our own biases, be they a product of our own training or practice. It also needs to be recognized that the literature can be biased, especially when

produced from an institutional rather than a population level. There is also the bias involved in accessing literature in other languages [56], which modern technology should help us address.

Austria, among other countries who have adopted universal US screening, has demonstrated that it can almost eliminate late diagnosis. The evidence that early detection and conservative treatment yields positive outcomes is compelling. As suggested by Holen *et al*. [15], this may particularly be an issue for countries with a high incidence of late diagnosis. The cost of not implementing universal screening is largely borne by a number of children, mostly girls, who are exposed to multiple surgeries and often poor outcomes.

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Conflicts of interest

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- ■ of special interest
- ■■ of outstanding interest

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