The management of developmental dysplasia of the hip under three months of age: A consensus study from the British Society for Children's Orthopaedic Surgery

Journal:	*The Bone & Joint Journal*
Manuscript ID	BJJ-2022-0893.R1
Manuscript Type:	Original Article
Keywords:	Developmental dysplasia of the hip, Screening, Consensus, Treatment

Title

The management of developmental dysplasia of the hip under three months of age: A consensus study from the British Society for Children's Orthopaedic Surgery

Abstract

Introduction

A national screening programme has existed in the UK for developmental dysplasia of the hip (DDH) since 1969, however controversy remains about every aspect of the screening and treatment. Screening programmes throughout the world vary enormously, and in the UK there is significant variation in screening practice and treatment pathways. The British Society for Children's Orthopaedic Surgery (BSCOS) tried to identify nationwide consensus in management of DDH to unify treatment, and suggest an approach for screening.

Methods

A Delphi consensus study was performed amongst the membership of BSCOS. Statements were generated by a steering group regarding aspects of DDH care in children less than three months old, namely screening / surveillance (15 questions), ultrasound scan technique (8 questions), initiation of treatment (19 questions), care during splint treatment (10 questions) and on quality, governance & research (8 questions). A two round Delphi processes was used and a consensus document was produced at the final steering group meeting.

Results

Sixty statements were graded by 128 clinicians in round one and 132 in round two. Consensus was reached on thirty out of sixty statements in round one, and an additional twelve in round two. This was summarised in a consensus statement and distilled into a flowchart to guide clinical practice.

Discussion

This study identified agreement in an area of medicine that has had long standing controversy and practice variation. These areas of consensus are, without exception, not based on high quality evidence. In the absence of evidence, this document is a framework to guide clinical practice upon which high quality clinical trials can be built.

Introduction

Developmental Dysplasia of the Hip (DDH) encompasses a spectrum of abnormalities, which range from mild acetabular deficiency through to subluxation and dislocation of the hip. 1 in 1000 newborns have a completely dislocated hip, and 2-3% are diagnosed with a degree of hip dysplasia.[1-4] It is widely believed that early detection and treatment in newborns using a simple splint rapidly restores normal anatomy, thus preventing lifelong abnormalities.[5-7] Detection outside the early infant period requires surgery to restore the hip into joint. This becomes increasingly complicated and associated with poorer outcomes as the child ages.[8-11] DDH is associated with premature osteoarthritis and is implicated in 10% of all hip replacements,[12] including a quarter in those under the age of 40.[13]

However there is wide variation in screening and treatment practices for DDH. Within the UK, screening guidelines are laid out in the Newborn and Infant Physical Examination (NIPE) programme for England and Wales, Scotland's 'Best Start' program and the Public Health Agency of Northern Ireland.[14-16] These programmes are based upon guidelines from the Standing Medical Advisory Committee, implemented in 1969 and updated in 1986.[17] Clinical examination is the first line screening tool, undertaken perinatally and repeated at six-weeks. A hip ultrasound scan (USS) is performed selectively for those with abnormal clinical examination findings or for those with defined risk factors. Despite the introduction of the screening programmes, there is a persistently high number of children requiring surgery for DDH.[7, 18-21] This suggests either a failure of screening pathways, or a failure of treatment pathways.

In countries such as Austria, Germany and Mongolia, all babies are screened using USS. In these countries the resulting late detection rate of hip dislocation is low.[3, 4, 22-27] Yet with potential over treatment and increased programme costs,[6, 22, 28-30] some bodies, including the United States Preventative Services Task Force, have not recommended any screening at all.[31] Regardless, the evidence upon which all these policies are based is insufficient.[7, 9, 32-36]

Further debate and practice variation exists in core aspects of DDH detection and treatment,[7, 37-40] notably the type of USS technique used,[41-46] which risk factors should trigger USS screening, optimal age at which to perform USS screening, which type of splint/brace/harness to use, optimal time to start treatment, and duration of treatment.[9, 14, 47-51] Not least, due to the natural maturation of a baby's hip with age, there remains debate on which hips require any treatment at all.[9, 52-54]. Such is the uncertainty that the UK national screening committee have stated *"If proposed now as a new programme, DDH screening would probably not be accepted. However, it is so ingrained in the clinical practice of so many people that it would be almost impossible to stop it unless overwhelming evidence of ineffectiveness could be obtained".*[55]

Determining the optimum DDH screening strategy has been identified as a top ten research priority for clinical effectiveness in children's orthopaedics in the UK.[56] In response, the British Society for Children's Orthopaedic Surgery (BSCOS) undertook a consensus exercise concerning the screening and treatment of infant hip dysplasia (DDH) before three months of age.[57] The aim was to establish consensus in the UK, where it exists, in order to minimise treatment variation and form a foundation upon which high quality intervention studies can be based.

Methods:

A modified Delphi approach was used to gather broad input from a diverse group of clinicians, whilst minimising domination by one or a few 'experts'.[58]

Establishing a steering group

Applications were invited in October 2019 from members and associate members of BSCOS to join the steering group. A group of twenty members was chosen, which consisted of nurses, physiotherapists and consultant paediatric orthopaedic surgeons. All declared an interest in the treatment of DDH in children, and currently undertook this in their routine clinical practice. This represented a diversity of professional occupations, experience and gender. From within this group a chairperson was elected (MK).

Steering group meetings

In response to the Covid-19 pandemic, all meetings were held virtually. Initial meetings involved brainstorming the topic. All steering group members submitted statements and questions to highlight areas of potential agreement and / or controversy. These statements were distilled into three topic areas, namely 'screening', 'ultrasound' and 'treatment'. Focused meetings were held on each topic separately. At each meeting, proposed statements were discussed and the text was formulated in a manner that was clear in its intent to all members of the steering group, as is standard practice for Delphi process based research. The total number of questions was limited to sixty, in order to maximise completion rate of the survey. A rigorous process of prioritisation of the key questions was performed over multiple steering group meetings. A literature review was performed relating to each point to confirm that there was no substantial evidence that would remove the need for the statement.

The Delphi process

The Delphi survey consisted of sixty focused statements on the management of DDH under three months of age. The statements were sub-divided into categories on screening / surveillance (15 questions), ultrasound scan technique (8 questions), initiation of treatment (19 questions), care during splint treatment (10 questions) and on quality, governance & research (8 questions).

The survey was sent to all members and associate members of BSCOS, who had opted in to receive such research invitations. The survey was distributed using the Jisc Online Survey tool.[59] Upon opening the survey, participants were initially instructed only to continue if they believed that they had the relevant experience and expertise to participate in this survey. The software restricted participation to only those invited to the study and similarly restricted one response per participant.

The BSCOS membership and associate membership were asked to grade the statements posed according to the following categories:

- Strong recommendation for;
- Conditional recommendation for;
- Recommendation for research;
- Conditional recommendation against;

- Strong recommendation against.

Consensus in favour of a statement was reached if 75% or more participants scored the statements as ‘Strong recommendation for’ or ‘Conditional recommendation for’ *and* less than 25% of participants scored it as ‘Strong recommendation against’ or ‘Conditional recommendation against’. Similarly, consensus against a statement was reached if 75% or more participants scored it as ‘Strong recommendation against’ or ‘Conditional recommendation against’ *and* less than 25% of participants scored it as ‘Strong recommendation for’ or ‘Conditional recommendation for’.

Membership feedback was sought during round 1 related to all questions and the broader process. Following round 1 the steering group refined some statements to avoid ambiguity. All statements that did not reach consensus from round 1 (either in favour or against) were taken forward to the round 2 survey. During the second round, the scores related to each statement at round 1 were provided to participants, alongside the statements for re-scoring.

Final consensus steering group meeting

A final consensus steering group meeting was hosted for discussion and development of the consensus document. This was set against a rigorous literature review.

Results

There were 128 responses to round one from 236 invitations (54%) and 132 responses to round two from 240 invitations (55%). This is a comparable response to the BSCOS clubfoot consensus project.[60] There were 20 and 21 participants respectively who declined to complete the survey due to their belief in not having the necessary experience and expertise. Thus the survey was completed by 108 participants in round one and 111 participants in round two. Of these, eleven (10%) were allied healthcare practitioners and the remainder were paediatric orthopaedic surgeons (90%).

Consensus was reached in thirty out of sixty statements in round one, and a further twelve statements reached consensus in round two. The statements in round one, along with their scores, are listed in Table 1. The refined statements for round two,

along with their scores, are listed in Table 2. The scores for statements at round one and round two are available as an Appendix.

Based upon the results of the Delphi exercise, a consensus statement has been produced (Box 1). To aid the impact of these statements in practice, this has been distilled into a flowchart focused on the treatment recommendations of DDH under three months of age (Figure 1). Aspects that did not reach consensus are highlighted in Figure 1 and detailed in Table 3.

Discussion

The Delphi process on management of DDH under 3 months of age has demonstrated areas of agreement, in an area of medicine with long standing debate and practice variation. Consensus was reached in 42 of 60 statements proposed by clinicians, with clarity given to the perceived optimal methods of screening and treatment for DDH. It is important to note that areas of consensus are, without exception, not based on high quality evidence and require focussed research. Nevertheless, in the context of uncertainty, consensus is a useful basis upon which guidelines can be standardised and a foundation from which evidence can be formulated.

A key difference from this study, compared to most international guidelines,[14-17, 31-34] was that consensus recommended a universal USS strategy. This consensus is in line with some European practice,[1, 3, 23] and a prior European DDH consensus group.[25] Undoubtedly the reason behind this outcome is the persistently high number of hips missed by the current UK system, which subsequently present late and result in surgery. The majority of respondents were surgeons who deal with these late detected cases. A further key outcome is the appetite for high quality research to address the uncertainties. The evidence base in children's orthopaedics has been strengthened by recent successful national cohort studies and randomised controlled trials.[61-63] The enthusiasm of the clinical community, combined with universal outcome collection tools such as Smart4NIPE, could enable efficient studies to be delivered across the UK. It is clear that whilst interventions for screening need to be tested, the downstream elements of the treatment pathway (i.e. how / when / who to treat) appear the highest priorities. Only by understanding the fundamentals of disease

and effective treatments can we begin to understand the effectiveness of screening.[64]

Like all studies, this consensus exercise has limitations. Whilst Delphi formulates the opinion amongst experts, allowing all to contribute equally, this should not replace rigorous scientific evidence. There may be instances whereby consensus does not reproduce, or even opposes, the evidence, owing to misinformation or competing interests amongst 'experts' from whom opinion is sought. There is a broader healthcare team who deliver elements of the screening pathway (i.e. midwives, radiographers, paediatricians, nurses, GPs and radiologists) than were involved in the consensus exercise. Broader engagement is planned in future studies, including patient and public involvement. Whilst only half of BSCOS members participated, there is no reason to believe that responders were different to non-responders, with responders appearing to broadly represent the make-up of the BSCOS membership. Whilst all respondents actively manage DDH in their routine clinical practice, this expertise is self declared. The study is UK focused, which could affect the generalisability if extrapolated outside of the NHS.

It is clear that decisions on screening programs and treatment protocols for DDH should be based upon the best possible evidence. In the absence of high quality evidence, such as in DDH management under three months of age, areas of consensus are the most robust means upon which to guide policy and practice. This document is therefore a framework for current clinical practice and the foundation on which to build future high quality clinical trials in the care of infants with DDH.

References

1. Biedermann R, Riccabona J, Giesinger JM, et al. Results of universal ultrasound screening for developmental dysplasia of the hip: a prospective follow-up of 28 092 consecutive infants. *Bone Joint J.* 2018;100-B(10):1399-1404.

2. Rosendahl K, Markestad T, Lie RT. Ultrasound screening for developmental dysplasia of the hip in the neonate: the effect on treatment rate and prevalence of late cases. *Pediatrics*. 1994;94(1):47-52.

3. Thallinger C, Pospischill R, Ganger R, Radler C, Krall C, Grill F. Long-term results of a nationwide general ultrasound screening system for developmental disorders of the hip: the Austrian hip screening program. *J Child Orthop*. 2014;8(1):3-10.

4. von Kries R, Ihme N, Oberle D, et al. Effect of ultrasound screening on the rate of first operative procedures for developmental hip dysplasia in Germany. *Lancet*. 2003;362(9399):1883-7.

5. Cashman JP, Round J, Taylor G, Clarke NMP. The natural history of developmental dysplasia of the hip after early supervised treatment in the Pavlik harness. A prospective, longitudinal follow-up. *J Bone Joint Surg Br*. 2002;84(3):418-25.

6. Clegg J, Bache CE, Raut VV. Financial justification for routine ultrasound screening of the neonatal hip. *J Bone Joint Surg Br*. 1999;81(5):852-7.

7. Jones DH, Dezateux CA, Danielsson LG, Paton RW, Clegg J. At the crossroads – neonatal detection of developmental dysplasia of the hip. *J Bone Joint Surg Br* 2000;82-B:160-4.

8. Eastwood DM. Neonatal hip screening. *Lancet*. 2003;361(9357):595-7.

9. Shorter D, Hong T, Osborn DA. Cochrane Review: Screening programmes for developmental dysplasia of the hip in newborn infants. *Evid Based Child Health*. 2013;8(1):11-54.

10. Terjesen T. Long-term outcome of closed reduction in late-detected hip dislocation: 60 patients aged six to 36 months at diagnosis followed to a mean age of 58 years. *J Child Orthop*. 2018;12(4):369–374.

11. Thomas SR, Wedge JH, Salter RB. Outcome at forty-five years after open reduction and innominate osteotomy for late-presenting developmental dislocation of the hip. *J Bone Joint Surg Am*. 2007;89(11):2341-50.

12. National Joint Registry - www.njrcentre.org.uk (last accessed July 2022)

13. Engesæter IØ, Lehmann T, Laborie LB, Lie SA, Rosendahl K, Engesæter LB. Total hip replacement in young adults with hip dysplasia: age at diagnosis, previous treatment, quality of life, and validation of diagnoses reported to the

Norwegian Arthroplasty Register between 1987 and 2007. *Acta Orthop.* 2011;82(2):149–154.

14. https://www.gov.uk/government/publications/newborn-and-infant-physical-examination-programme-handbook/nipe-newborn-hip-screening-screen-positive-pathway (last accessed July 2022)

15. https://www.isdscotland.org/Health-topics/Child-health/Child-Health-Programme/_docs/CHSP-PS-Clinical-Guidelines-2018-06-26-FINAL.pdf (last accessed July 2022)

16. https://www.nidirect.gov.uk/articles/newborn-screening (last accessed July 2022)

17. Standing Medical Advisory Committee and Standing Nursing and Midwifery Advisory Committee Working Party. Screening for the detection of congenital dislocation of the hip. *Arch Dis Child.* 1986;61:921-6.

18. Broadhurst C, Rhodes AML, Harper P, Perry DC, Clarke NMP, Aarvold A. What is the incidence of late detection of developmental dysplasia of the hip in England?: a 26-year national study of children diagnosed after the age of one. *Bone Joint J*. 2019;101-B(3):281-287.

19. Düppe H, Danielsson LG. Screening of neonatal instability and of developmental dislocation of the hip. A survey of 132,601 living newborn infants between 1956 and 1999. *J Bone Joint Surg Br*. 2002;84(6):878-85.

20. Godward S, Dezateux C. Surgery for congenital dislocation of the hip in the UK as a measure of outcome of screening. MRC Working Party on Congenital Dislocation of the Hip. Medical Research Council. *Lancet*. 1998;351(9110):1149-52.

21. Milligan DJ, Cosgrove AP. Monitoring of a hip surveillance programme protects infants from radiation and surgical intervention. *Bone Joint J*. 2020;102-B(4):495-500.

22. Biedermann R, Eastwood DM. Universal or selective ultrasound screening for developmental dysplasia of the hip? A discussion of the key issues. *J Child Orthop.* 2018;12:296-301.

23. Ihme N, Altenhofen L, von Kries R, Niethard FU. [Hip ultrasound screening in Germany. Results and comparison with other screening procedures]. *Orthopade*. 2008 Jun;37(6):541-6, 548-9.

24. Jung HW, Jang WY. Effectiveness of different types of ultrasonography screening for developmental dysplasia of the hip: A meta-analysis. *Medicine*. 2020;99(50):e23562.

25. O'Beirne JG, Chlapoutakis K, Alshryda S, et al. International Interdisciplinary Consensus Meeting on the Evaluation of Developmental Dysplasia of the Hip. *Ultraschall Med*. 2019;40(4):454-464.

26. Ulziibat M, Munkhuu B, Schmid R, Baumann T, Essig S. Implementation of a nationwide universal ultrasound screening programme for developmental dysplasia of the neonatal hip in Mongolia. *J Child Orthop.* 2020;14(4):273-280.

27. von Kries R, Ihme N, Altenhofen L, Niethard FU, Krauspe R, Rückinger S. General ultrasound screening reduces the rate of first operative procedures for developmental dysplasia of the hip: a case-control study. J Pediatr. 2012;160(2):271-5.

28. Harper P, Gangadharan R, Poku D, Aarvold A. Cost Analysis of Screening Programmes for Developmental Dysplasia of the Hip: A Systematic Review. *Indian J Orthop*. 2021;55(6):1402-1409.

29. Thaler M, Biedermann R, Lair J, Krismer M, Landauer F. Cost-effectiveness of universal ultrasound screening compared with clinical examination alone in the diagnosis and treatment of neonatal hip dysplasia in Austria. *J Bone Joint Surg Br*. 2011;93(8):1126-30.

30. Woodacre T, Dhadwal A, Ball T, Edwards C, Cox PJA. The costs of late detection of developmental dysplasia of the hip*. J Child Orthop*. 2014;8(4):325-32.

31. US Preventive Services Task Force. https://www.uspreventiveservicestaskforce.org/uspstf/document/RecommendationStatementFinal/developmental-hip-dysplasia-screening (last accessed July 2022)

32. American Academy of Orthopedic Surgeons. https://www.aaos.org/globalassets/quality-and-practice-resources/pddh/pddhcpg.pdf (last accessed July 2022)

33. American Academy of Pediatrics. https://publications.aap.org/pediatrics/article-abstract/117/3/898/68606/Screening-for-Developmental-Dysplasia-of-the-Hip (last accessed July 2022)

34. American Academy of Pediatrics. https://publications.aap.org/pediatrics/article/136/4/e1141/73871/Guideline-on-Detection-and-Nonoperative-Management (last accessed July 2022)

35. Cooper AP, Doddabasappa SN, Mulpuri K. Evidence-based management of developmental dysplasia of the hip. *Orthop Clin North Am*. 2014;45(3):341-54.

36. Talbot C, Adam J, Paton R. Late presentation of developmental dysplasia of the hip : a 15-year observational study. *Bone Joint J.* 2017;99-B(9):1250-1255.

37. Mulpuri K, Schaeffer EK, Kelley SP, et al. What Is the Impact of Center Variability in a Multicenter International Prospective Observational Study on Developmental Dysplasia of the Hip? *Clin Orthop Relat Res*. 2016;474(5):1138-45.

38. Paton RW. Does selective ultrasound imaging of 'at risk' hips and clinically unstable hips, in developmental dysplasia of the hip (DDH) produce an effective screening programme. 2011; uk.bl.ethos.618306

39. Pinto D, Aroojis A, Shah H, et al. Demographic and Practice Variability Amongst Indian Centres in a Multicentre Prospective Observational Study on Developmental Dysplasia of the Hip. *Indian J Orthop*. 2021;55(6):1559-1567.

40. Westacott DJ, Perry DC. The treatment of neonatal hip dysplasia with splints in the United Kingdom: time for consensus? *J Child Orthop*. 2020;14(2):112-117.

41. Graf, R. The diagnosis of congenital hip-joint dislocation by the ultrasonic combound treatment. *Arch Orth Traum Surg*. 1980;97:117–133.

42. Harcke, H. Examination of the infant hip with real-time ultrasonography. *J Ultrasound Med.* 1984;3(3):131-7.

43. Suzuki S, Kasahara Y, Futami T, Ushikubo S, Tsuchiya T. Ultrasonography in congenital dislocation of the hip. Simultaneous imaging of both hips from in front. *J Bone Joint Surg Br*. 1991;73(6):879-83.

44. Terjesen T, Bredland T, Berg V. Ultrasound for hip assessment in the newborn. *J Bone Joint Surg Br*. 1989;71(5):767-73.

45. Kotlarsky P, Haber R, Bialik V, Eidelman M. Developmental dysplasia of the hip: What has changed in the last 20 years? *World J Orthop*. 2015;6(11):886-901.

46. Rosendahl K, Toma P. Ultrasound in the diagnosis of developmental dysplasia of the hip in newborns. The European approach. A review of methods, accuracy and clinical validity. Eur Radiol. 2007;17(8):1960-7.

47. Holen KJ, Tegnander A, Eik-Nes SH, Terjesen T. The use of ultrasound in determining the initiation of treatment in instability of the hip in neonates. *J Bone Joint Surg Br*. 1999;81(5):846-51.

48. Tan SHS, Wong KL, Lim AKS, Hui JH. The earliest timing of ultrasound in screening for developmental dysplasia of the hips. *Ultrasonography*. 2019;38(4):321-326.

49. Behman AL, Bradley CS, Maddock CL et al. Testing of an Ultrasound-Limited Imaging Protocol for Pavlik harness Supervision (TULIPPS) in developmental dysplasia of the hip: a randomized controlled trial. Bone Joint Journal. 2022;104-B(9):1081.

50. Lyu X, Chen T, Yang Z et al. Tübingen hip flexion splint more successful than Pavlik harness for decentred hips after the age of three months. Bone Joint Journal. 2021;103-B(5):991.

51. Kelley SP, Feeney MM, Maddock CL et al. Expert-Based Consensus on the Principles of Pavlik Harness Management of Developmental Dysplasia of the Hip. JBJS Open Access 2019;4(4):e0054

52. Barlow T. Early diagnosis and treatment of congenital dislocation of the hip. *J Bone Joint Surg*. 1962;44:292-301.

53. Lee CB, Mata-Fink A, Millis MB, Kim YJ. Demographic differences in adolescent-diagnosed and adult-diagnosed acetabular dysplasia compared with infantile developmental dysplasia of the hip. *J Pediatr Orthop*. 2013;33(2):107-11.

54. Pollet V, Castelein RM, van de Sande M, et al. Abduction treatment in stable hip dysplasia does not alter the acetabular growth: results of a randomized clinical trial. *Sci Rep*. 2020;10(1):9647.

55. National Screening Committee. Child Health Sub-Group Report. Dysplasia of the hip. 2004. https://view-health-screening-recommendations.service.gov.uk/developmental-dislocation-of-the-hip/ (last accessed July 2022)

56. Perry DC, Wright JG, Cooke S, et al. A consensus exercise identifying priorities for research into clinical effectiveness among children's orthopaedic surgeons in the United Kingdom. *Bone Joint J*. 2018;100-B(5):680-684.

57. British Society for Children's Othopaedic Surgery. https://www.bscos.org.uk/consensus/consensus/groups.php (last accessed July 2022)

58. Boulkedid R, Abdoul H, Loustau M, Sibony O, Alberti C. Using and reporting the Delphi method for selecting healthcare quality indicators: a systematic review. *PLoS One.* 2011;6(6):e20476.

59. Jisc Online Surveys. www.onlinesurveys.ac.uk

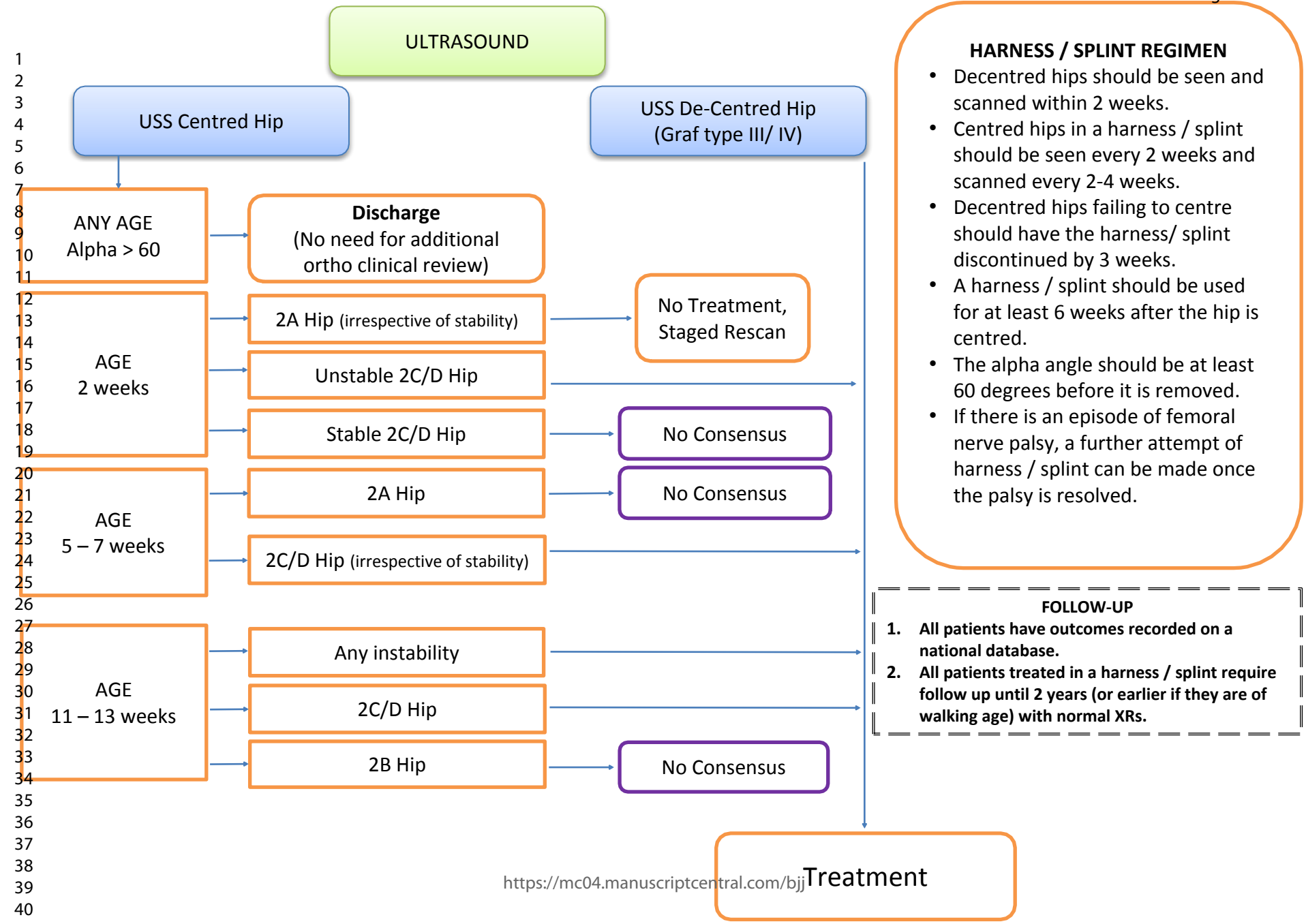
60. Gelfer Y, Davis N, Blanco J, et al. Attaining a British consensus on managing idiopathic congenital talipes equinovarus up to walking age. *Bone Joint J*. 2022 Jun;104-B(6):758-764.

61. Perry DC, Arch B, Appelbe D, et al. The British Orthopaedic Surgery Surveillance study: slipped capital femoral epiphysis: the epidemiology and two-year outcomes from a prospective cohort in Great Britain. *Bone Joint J.* 2022;104-B(4):519-528.

62. Perry DC, Arch B, Appelbe D, et al. The British Orthopaedic Surgery Surveillance study: Perthes' disease: the epidemiology and two-year outcomes from a prospective cohort in Great Britain. Bone Joint J. 2022;104-B(4):510-518.

63. Perry DC, Achten J, Knight R, et al. Immobilisation of torus fractures of the wrist in children (FORCE): a randomised controlled equivalence trial in the UK. *Lancet*. 2022;400(10345):39-47.

64. National Screening Committee's criteria for appraising the viability, effectiveness, and appropriateness of a screening programme. https://www.bmj.com/content/suppl/2001/04/19/322.7292.986.DC1 (last accessed July 2022)



HARNESS / SPLINT REGIMEN

- Decentred hips should be seen and scanned within 2 weeks.
- Centred hips in a harness / splint should be seen every 2 weeks and scanned every 2-4 weeks.
- Decentred hips failing to centre should have the harness/ splint discontinued by 3 weeks.
- A harness / splint should be used for at least 6 weeks after the hip is centred.
- The alpha angle should be at least 60 degrees before it is removed.
- If there is an episode of femoral nerve palsy, a further attempt of harness / splint can be made once the palsy is resolved.

FOLLOW-UP

1. **All patients have outcomes recorded on a national database.**
2. **All patients treated in a harness / splint require follow up until 2 years (or earlier if they are of walking age) with normal XRs.**

Table 1 Descriptive analysis of statements included in the Delphi survey Round 1. Green shading represents 'Consensus for', red shading represents 'Consensus against' and statements not shaded are those which did not reach consensus.

	BSCOS Respondents (n=108)				
	N (%)				
	Strong Recommend-ation *For*	Conditional Recommend-ation *For*	Recommendation for research and possibly conditional recommendation for use restricted to trials	Conditional Recommend-ation *Against*	Strong Recommend-ation *Against*
Screening and Surveillance					
1. Some form of screening/surveillance should be undertaken to identify cases of DDH in babies.	102 (94)	4 (4)	1 (1)	0 (0)	1 (1)
2. In the context of the current delivery, the assessment of clinical instability at birth has low accuracy and alternative screening pathways should be considered.	46 (43)	29 (27)	25 (23)	7 (6)	1 (1)
3. In the context of the current delivery, universal neonatal clinical examination should be removed.	2 (2)	4 (4)	15 (14)	22 (20)	65 (60)
4. "Clicky hips" without instability (i.e. Barlow and Ortolani assessed to be normal) should be referred for a hip USS.	30 (28)	29 (27)	21 (19)	15 (14)	13 (12)
5. So called packaging disorders (torticollis; plagiocephaly; metatarsus adductus) should be included as risk factors for DDH.	42 (39)	36 (33)	22 (20)	4 (4)	4 (4)
6. First born females should be included as risk factors for DDH.	29 (27)	29 (27)	29 (27)	16 (15)	5 (5)
7. High birth weight females (>4KG) should be included as risk factors for DDH.	22 (20)	28 (26)	33 (31)	15 (14)	10 (9)
8. CTEV should be included as risk factors for DDH.	35 (32)	32 (30)	24 (22)	11 (10)	6 (6)
9. Foot deformities (non CTEV) should be included as risk factors for DDH.	30 (28)	45 (42)	22 (20)	8 (7)	3 (3)
10. The UK screening/surveillance program should involve universal ultrasound examination.	47 (44)	22 (20)	16 (15)	14 (13)	9 (8)

11. In the context of the UK screening programme, a 6 - 8 week clinical check in the community should be obligatory.	65 (60)	25 (23)	8 (7)	6 (6)	4 (4)
12. Children undergoing a hip USS must always have a clinical examination alongside the USS.	47 (44)	16 (15)	19 (18)	15 (14)	11 (10)
13. In a *universal* USS screening/surveillance program all hips can wait until 4-6 weeks for their USS?	28 (26)	26 (24)	22 (20)	18 (17)	14 (13)
14. In a *selective* USS screening/surveillance program all hips can wait until 4-6 weeks for their USS?	17 (16)	32 (30)	18 (17)	24 (22)	17 (16)
15. In a *selective* USS *s*creening/surveillance program all children with abnormal neonatal examination must receive an USS by 2 weeks.	43 (40)	28 (26)	18 (17)	15 (14)	4 (4)
Ultrasound					
16. The Graf method of scanning using a cradle and probe holder should be mandatory for hip USS when using static scans.	31 (29)	37 (34)	21 (19)	6 (6)	13 (12)
17. The Graf criteria of standardised *reporting* should be employed in its unmodified form (Age/Useability/Description/Measurement/Classification).	34 (31)	38 (35)	19 (18)	8 (7)	9 (8)
18. In order to accurately measure the Alpha angle the *minimum* requirement of an acceptable coronal plane scan must include visualisation of a straight ilium, the acetabular labrum and the lower limb of the ischium (where the triradiate cartilage begins).	74 (69)	27 (25)	4 (4)	2 (2)	1 (1)
19. The core minimum criteria to be assessed and documented should include whether the hip is centred.	79 (73)	20 (19)	2 (2)	4 (4)	3 (3)
20. The core minimum criteria to be assessed and documented should include measurement of the alpha angle.	73 (68)	22 (20)	8 (7)	4 (4)	1 (1)
21. The core minimum criteria to be assessed and documented should include measurement of the beta angle.	15 (14)	28 (26)	35 (32)	19 (18)	11 (10)

22. The core minimum criteria to be assessed and documented should include *sonographic* dynamic test of stability.	48 (44)	29 (27)	16 (15)	12 (11)	3 (3)
23. The core minimum criteria to be assessed and documented should include the description of head coverage in terms of percentage.	35 (32)	30 (28)	27 (25)	10 (9)	6 (6)
Initiation Of Brace Treatment					
24. Babies who have had a screening ultrasound scan can be discharged, without examination, in the presence of a normal scan.	42 (39)	32 (30)	6 (6)	15 (14)	13 (12)
At **2 weeks of age or less**, with an ***unstable*** hip on physical examination:					
25. The de-centred hip (equivalent Graf 3 or greater) should be treated.	84 (78)	16 (15)	3 (3)	4 (4)	1 (1)
26. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	55 (51)	27 (25)	14 (13)	8 (7)	4 (4)
27. The centred hip, alpha angle 50–59 (equivalent Graf 2a) should be treated.	14 (13)	15 (14)	21 (19)	23 (21)	35 (32)
At **2 weeks of age or less**, with a ***stable*** hip on physical examination:					
28. The de-centred hip (equivalent Graf 3 or greater) should be treated.	69 (64)	18 (17)	9 (8)	9 (8)	3 (3)
29. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	39 (36)	19 (18)	19 (18)	18 (17)	13 (12)
30. The centred hip, alpha angle 50-59 (equivalent Graf 2a) should be treated.	1 (1)	3 (3)	13 (12)	35 (32)	56 (52)
At **5-7 weeks of age**, with an ***unstable*** hip on physical examination:					
31. The de-centred hip (equivalent Graf 3 or greater) should be treated.	104 (96)	4 (4)	0 (0)	0 (0)	0 (0)
32. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	92 (85)	14 (13)	1 (1)	1 (1)	0 (0)
33. The centred hip, alpha angle 50-59 (equivalent Graf 2a) should be treated.	51 (47)	18 (17)	17 (16)	13 (12)	9 (8)
At **5-7 weeks of age**, with a ***stable*** hip on physical examination:					
34. The de-centred hip (equivalent Graf 3 or greater) should be treated.	83 (77)	18 (17)	5 (5)	0 (0)	2 (2)
35. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	69 (64)	21 (19)	12 (11)	2 (2)	4 (4)
36. The centred hip, alpha angle 50-59 (equivalent Graf 2a) should be treated.	6 (6)	15 (14)	28 (26)	27 (25)	32 (30)
At **11-13 weeks of age**, with an ***unstable*** hip on physical examination:					
37. The de-centred hip (equivalent Graf 3 or greater) should be treated.	97 (90)	7 (6)	0 (0)	1 (1)	3 (3)
38. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	96 (89)	8 (7)	2 (2)	1 (1)	1 (1)

39. The centred hip, alpha angle 50–59 (equivalent Graf 2b) should be treated.	78 (72)	14 (13)	8 (7)	6 (6)	2 (2)
At **11-13 weeks of age**, with a ***stable*** hip on physical examination:					
40. The de-centred hip (equivalent Graf 3 or greater) should be treated.	88 (81)	9 (8)	4 (4)	4 (4)	3 (3)
41. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	80 (74)	13 (12)	10 (9)	2 (2)	3 (3)
42. The centred hip, alpha angle 50–59 (equivalent Graf 2b) should be treated.	32 (30)	23 (21)	25 (23)	14 (13)	14 (13)
Hips Undergoing Brace Treatment					
43. In a hip that is undergoing treatment in a harness/splint, once the hip is centred on ultrasound, the harness can be stopped, regardless of persistent dysplasia at that point.	0 (0)	4 (4)	15 (14)	35 (32)	54 (50)
44. In a hip that is undergoing treatment in a harness/splint, once the hip is centred on ultrasound, treatment should continue at least until the hip is sonographically mature (alpha >60).	53 (49)	37 (34)	11 (10)	7 (6)	0 (0)
45. Following full time harnessing/splinting, a period of weaning is required.	4 (4)	19 (18)	33 (31)	26 (24)	26 (24)
46. It is safe to re-commence splintage once femoral nerve palsy has resolved.	31 (29)	58 (54)	10 (9)	6 (6)	3 (3)
47. Hips that have been treated and normalised in a harness can be discharged with no further follow up.	2 (2)	1 (1)	13 (12)	24 (22)	68 (63)
Quality, Governance and Research					
48. A screening/surveillance program must be linked to paediatric orthopaedic service.	85 (79)	14 (13)	6 (6)	3 (3)	0 (0)
49. A one stop service (i.e. same day diagnosis & initiation of treatment) is gold standard.	88 (81)	16 (15)	3 (3)	0 (0)	1 (1)
50. There should be a quality assurance process for everyone performing clinical examination of baby hips.	82 (76)	18 (17)	7 (6)	1 (1)	0 (0)
51. A small group of expert examiners should be responsible for performing baby hip screening/surveillance in each maternity setting.	60 (56)	34 (31)	9 (8)	3 (3)	2 (2)
52. There should be a quality assurance process for everyone performing USS examination of baby hips.	89 (82)	17 (16)	2 (2)	0 (0)	0 (0)

53. Centres undertaking hip USS as part of a screening/surveillance must have a quality assurance system in place.	85 (79)	21 (19)	2 (2)	0 (0)	0 (0)
54. A trial of selective vs. universal USS screening/surveillance is warranted.	56 (52)	18 (17)	24 (22)	4 (4)	6 (6)
55. There should be a national data collection system for DDH, through which referrals and treatment outcomes should be routinely collected.	58 (54)	33 (31)	15 (14)	2 (2)	0 (0)

56. De-centred hips put in a brace should be seen and scanned regularly within:	
1 week	35 (32)
2 weeks	61 (57)
3 weeks	7 (7)
4 weeks	2 (2)
5 weeks	0 (0)
6 weeks	3 (3)

57. Centred hips put in a brace should be seen and scanned regularly within:	
1 week	10 (9)
2 weeks	39 (36)
3 weeks	13 (12)
4 weeks	27 (25)
5 weeks	0 (0)
6 weeks	17 (16)
8 weeks	2 (2)

58. Once the hip is centred, the harness/splint should be checked / adjusted at least every:	
1 week	10 (9)
2 weeks	52 (48)
3 weeks	14 (13)
4 weeks	13 (12)
According to clinical or parent needs	19 (18)

59. Once a hip is centred then treatment should continue for a minimum:	
0 weeks	7 (7)
2 weeks	10 (9)
4 weeks	22 (20)
6 weeks	58 (54)
8 weeks	5 (5)
10 weeks	6 (6)

60. Hips that have been treated and normalised in a harness must be routinely followed at least until:	
1 year	13 (12)
18 months	6 (6)
2 years	21 (19)
3 years	3 (3)
4 years	6 (6)
5 years	17 (16)
Walking age with normal radiographs	42 (39)

Table 2 Descriptive analysis of statements included in the Delphi survey Round 2. Shading is as in Table 1.

	BSCOS Respondents (n=111)				
	N (%)				
	Strong Recommend-ation *For*	Conditional Recommend-ation *For*	Recommendation for research and possibly conditional recommendation for use restricted to trials	Conditional Recommend-ation *Against*	Strong Recommend-ation *Against*
Screening and Surveillance					
1. The assessment of clinical instability at birth has low accuracy and alternative screening pathways should be considered.	61 (55)	25 (23)	19 (17)	3 (3)	3 (3)
2. “Clicky hips” without instability (i.e. Barlow and Ortolani assessed to be normal) should be referred for a hip USS.	47 (42)	31 (28)	17 (15)	9 (8)	7 (6)
3. So called packaging disorders (torticollis; plagiocephaly; metatarsus adductus) should be included as risk factors for DDH.	72 (64)	26 (23)	8 (7)	3 (3)	2 (2)
4. First born females should be included as risk factors for DDH.	42 (38)	27 (24)	31 (28)	4 (4)	7 (6)
5. High birth weight females (>4KG) should be included as risk factors for DDH.	23 (21)	22 (20)	51 (46)	9 (8)	6 (5)
6. CTEV should be included as risk factors for DDH.	46 (41)	30 (27)	16 (14)	13 (12)	6 (5)
7. Foot deformities (non CTEV) should be included as risk factors for DDH.	38 (34)	52 (47)	12 (11)	6 (5)	3 (3)
8. The UK screening/surveillance program should involve universal ultrasound examination.	70 (63)	16 (14)	13 (12)	8 (7)	4 (4)
9. Children undergoing a hip USS must always have a clinical examination alongside the USS.	64 (58)	14 (13)	14 (13)	14 (13)	5 (5)
10. In a universal USS screening/surveillance program all hips can wait until 4-6 weeks for their USS?	44(40)	29 (26)	11 (10)	14 (13)	13 (12)

11. In a selective USS screening/surveillance program all hips can wait until 4-6 weeks for their USS?	25 (23)	44 (40)	7 (6)	24 (22)	11 (10)
12. In a selective USS screening/surveillance program all children with abnormal neonatal examination must receive an USS by 2 weeks.	63 (57)	29 (26)	7 (6)	6 (5)	6 (5)
Ultrasound					
13. The Graf method of scanning using a cradle and probe holder should be mandatory for hip USS when using static scans.	40 (36)	34 (31)	16 (14)	7 (6)	14 (13)
14. The Graf criteria of standardised reporting should be employed in its unmodified form (Age/Useability/Description/Measurement/Classification).	30 (27)	54 (49)	12 (11)	7 (6)	8 (7)
15. The core minimum criteria to be assessed and documented must always include whether the hip is centred.	102 (92)	7 (6)	2 (2)	0 (0)	0 (0)
16. The core minimum criteria to be assessed and documented must always include measurement of the alpha angle.	95 (86)	7 (6)	5 (5)	2 (2)	2 (2)
17. The core minimum criteria to be assessed and documented must always include measurement of the beta angle.	8 (7)	17 (15)	61 (55)	10 (9)	15 (14)
18. The core minimum criteria to be assessed and documented must always include sonographic dynamic test of stability i.e. an ultrasound stress test.	68 (61)	24 (22)	8 (7)	4 (4)	7 (6)
19. The core minimum criteria to be assessed and documented must always include the description of head coverage in terms of percentage.	51 (46)	26 (23)	22 (20)	5 (5)	7 (6)
Initiation Of Treatment In A Harness/Splint					
20. Babies who have had a screening ultrasound scan can be discharged, without examination, in the presence of a normal scan.	72 (65)	23 (21)	6 (5)	3 (3)	7 (6)
At 2 weeks of age or less, with an unstable hip on physical examination:					
21. The centred hip, alpha angle 50–59 (equivalent Graf 2a), should not be immediately treated, but a staged re-scan should occur.	56 (51)	28 (25)	10 (9)	8 (7)	9 (8)

22. The centred hip, alpha angle 50–59 (equivalent Graf 2a) should be treated.	11 (10)	9 (8)	13 (12)	26 (23)	52 (47)
At 2 weeks of age or less, with a stable hip on physical examination:					
23. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D), should not be immediately treated, but a staged re-scan should occur.	21 (19)	33 (30)	19 (17)	11 (10)	27 (24)
24. The centred hip, alpha angle 43-49 (equivalent Graf 2c or D) should be treated.	45 (41)	26 (23)	13 (12)	16 (14)	11 (10)
At 5-7 weeks of age, with a stable hip on physical examination:					
25. The centred hip, alpha angle 50-59 (equivalent Graf 2a), should not be immediately treated, but a staged re-scan should occur.	47 (42)	35 (32)	13 (12)	12 (11)	4 (4)
26. The centred hip, alpha angle 50-59 (equivalent Graf 2a) should be treated.	3 (3)	14 (13)	19 (17)	26 (23)	49 (44)
At 11-13 weeks of age, with a stable hip on physical examination:					
27. The centred hip, alpha angle 50–59 (equivalent Graf 2b) should be treated.	67 (60)	14 (13)	17 (15)	8 (7)	5 (5)
Hips Undergoing Treatment In A Harness/Splint					
28. Following full time harnessing/splinting, a period of weaning is required.	4 (4)	8 (7)	41 (37)	11 (10)	47 (42)
Quality, Governance and Research					
29. A trial of selective vs. universal USS screening/surveillance is warranted.	80 (72)	10 (9)	12 (11)	5 (5)	4 (4)

30. De-centred hips treated in a harness / splint should be seen and scanned within:

1 week	18 (16)
2 weeks	89 (80)
3 weeks	3 (3)
4 weeks	1 (1)
5 weeks	0 (0)
6 weeks	0 (0)

31. Centred hips treated in a harness / splint should be scanned at the following intervals:

1 week	3 (3)
2 weeks	51 (46)
3 weeks	8 (7)
4 weeks	31 (28)
5 weeks	0 (0)
6 weeks	17 (15)
8 weeks	1 (1)

32. Centred hips treated in a harness / splint should be seen for harness / splint adjustment at the following intervals:

1 week	17 (15)
2 weeks	69 (62)
3 weeks	7 (6)
4 weeks	8 (7)
According to clinical or parent needs	10 (9)

33. A de-centred hip that fails to centre should have the harness / splint discontinued within:

1 week	9 (8)
2 weeks	55 (50)
3 weeks	28 (25)
4 weeks	18 (16)
5 weeks	0 (0)
6 weeks	1 (1)

34. Once a hip is centred then treatment should continue for a minimum:

0 weeks	2 (2)
2 weeks	3 (3)
4 weeks	13 (12)
6 weeks	80 (72)
8 weeks	5 (5)
10 weeks	2 (2)
12 weeks	6 (5)
35. Hips that have been treated and normalised in a harness must be routinely followed at least until:	
1 year	5 (5)
18 months	3 (3)
2 years	20 (18)
3 years	2 (2)
4 years	3 (3)
5 years	18 (16)
Walking age and with normal radiographs	60 (54)

Table 3 Numerous aspects did not reach consensus. These are summarised in the following table.

1. **There was no consensus on whether all hips can wait until 4-6 weeks before an USS is undertaken.**
2. **In the context of a selective USS programme, there was no consensus on whether 'clicky' hips, first born females, high birth weight females (>4kg) or CTEV should be included as risk factors for DDH.**
3. **When undertaking the USS, there was no consensus on whether a Graf cradle and probe holder should be mandatory.**
4. **When undertaking the USS, there was no consensus on whether the core minimum criteria to be assessed and documented should include beta angle and description of femoral head coverage in terms of percentage.**
5. **There was no consensus on whether a period of weaning is required at the end of a harness / splint regime**

Regarding treatment, there was no consensus was reached on whether the following hips at the following timepoints warranted treatment in a harness / splint:

6. The Graf 2c / D hip at 2 weeks of age (immediate treatment versus staged re-scan).
7. The 2a hip at 5-7 weeks of age (immediate treatment versus staged re-scan).
8. The 2b hip at 11-13 weeks of age.

Box 1: The BSCOS consensus statement for the management of DDH under 3 months of age

BSCOS believe that surveillance for DDH is valuable, but recognise that the current model of clinical screening has low accuracy and alternative models should be sought. Nevertheless, at present we believe that the current system of screening using clinical examination at birth and a 6-8 week community examination should continue. The examination should be performed by a small group of 'expert' examiners in the maternity setting, and there should be methods of quality assurance in place for all professionals undertaking the examination. All surveillance systems must be linked to a children's orthopaedic service.

BSCOS advocates for universal ultrasound screening and believes that a randomised clinical trial is necessary to compare universal ultrasound screening to the current screening pathway.

BSCOS believe that, in the context of selective USS screening / surveillance, children with an abnormal neonatal clinical examination must have an ultrasound scan within 2 weeks. In addition to the current 'risk factors' prompting an ultrasound scan, we believe that 'non-CTEV foot deformities' (i.e. metatarsus adductus / calcaneovalgus) and 'packaging disorders' should be included as risk factors.

Ultrasound scans should take place in a 'one stop clinic', such that treatment can be started at the time of the scan if required. There should be a system of quality assurance in place at both an individual and centre level to ensure the quality of the ultrasound assessment. The Graf criteria of standardised reporting should be employed (i.e. using the headings 'Age' / 'Useability' / 'Description' / 'Measurement' / 'Classification'). To accurately measure Alpha angle, the minimum requirement of an acceptable coronal plane scan must include visualisation of a straight ilium, the acetabular labrum and the lower limb of the ilium (where the triradiate cartilage begins). The core minimum criteria to be assessed and documented on every scan should include: whether the hip is centred; the alpha angle (providing the hip is centred); *sonographic* dynamic test of stability.