

Hip sonography: background; technique and common mistakes; results; debate and politics; challenges

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ABSTRACT

Developmental dysplasia of the hip (DDH) is the commonest 'congenital' disease of the locomotor system throughout the world. According to the World Health Organisation (WHO) Bone & Joint Decade (2000-2010) 10%-15% of patients who are under the age of 50 when they require a hip replacement do so because of infant hip dysplasia. The background; technique and common mistakes; results; debate and politics; and the challenges of infant hip sonography are reviewed.

Keywords: Congenital hip luxation, DDH, Graf-technique, Hip ultrasound

Editor's Introduction

Following recognition of Professor Graf's lifetime work by the European Hip Society, when he was made an Honorary Member of the EHS at our annual meeting in Munich 2016, I am delighted to publish his paper sharing his observations on hip sonography of the infant. It is a great privilege to have such a world-renowned orthopaedic surgeon share his work and clarify his technique with the readership of Hip International.

Introduction and historical background

Developmental dysplasia of the hip (DDH) is the commonest 'congenital' disease of the locomotor system throughout the world. According to the World Health Organisation (WHO) Bone & Joint Decade (2000-2010) 10%-15% of patients who are under the age of 50 when they require a hip replacement do so because of infant hip dysplasia.

The introduction of the neonatal clinical examination as described by Ortolani and Barlow (1) in an attempt to detect DDH as early as possible combined with the recognition of risk factors was major progress. However, it has not solved the problem. So-called "neglected" late presenting cases with head necrosis and severely damaged joints are still seen. We now know this is because 54% of dislocations have no clinical signs including no Ortolani sign and no risk factors (1). Nor

can routine x-rays solve the problem. Radiation is hazardous and only shows bone so cannot show most of the baby hip joint, which is formed of cartilage.

This failure of clinical screening was the reason that in the late 1970s we began to explore whether ultrasound could be used to see the anatomical structures formed of hyaline cartilage in a baby hip joint namely the femoral head and acetabular roof. Also, was it possible using ultrasound to see the position of the femoral head in a baby's hip joint? (2). Everybody laughed when the first results were presented: "Graf with his weather forecast, fog and clouds" (Fig. 1). However, not only were both of these possible but in addition ultrasound has led to a much greater understanding of the anatomy and pathophysiology of the infant hip.

We have continued systematically to develop a method for ultrasound examination of the infant hip. All the mistakes which are made today by the other techniques, including modifications of "Graf" (3-5) we made in the early 1980s (6, 7). The precise standardised technique which we use today (8-10) has been accepted by the healthcare systems in several countries. General ultrasound screening of all newborns was introduced in Austria (1991), Switzerland (1995) and Germany (1996) resulting in a dramatic fall in the rate of open reductions, Dega or Salter osteotomies and head necrosis. In addition, the costs of DDH diagnosis and treatment have been dramatically reduced (10-14). The motto "Prevention is better than operation" holds true.

Current aims of hip sonography today

- To detect the pre-dislocation stage (Type IIc). That is to detect joints which have no clinical signs but are nonetheless dysplastic and may progress to dislocation (DDH).
- To identify and describe (sonographic type) the pathology inside the joint when there is a dislocation.

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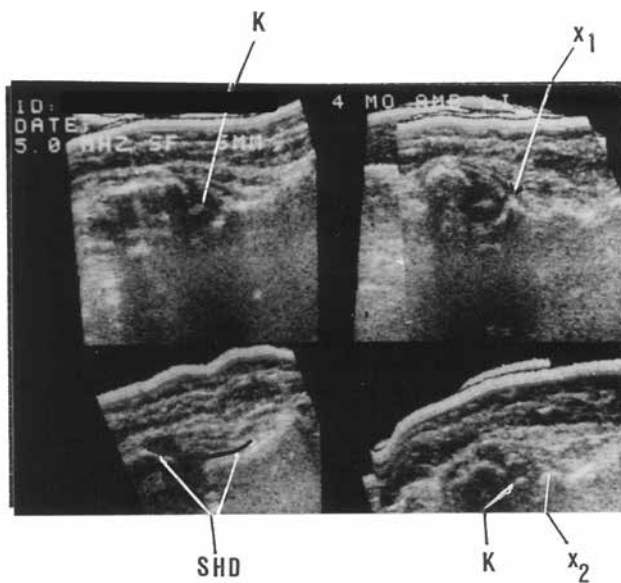


Fig. 1 - One of the very first hip sonograms (1979) made with a compound transducer, the nucleus is marked with "K".

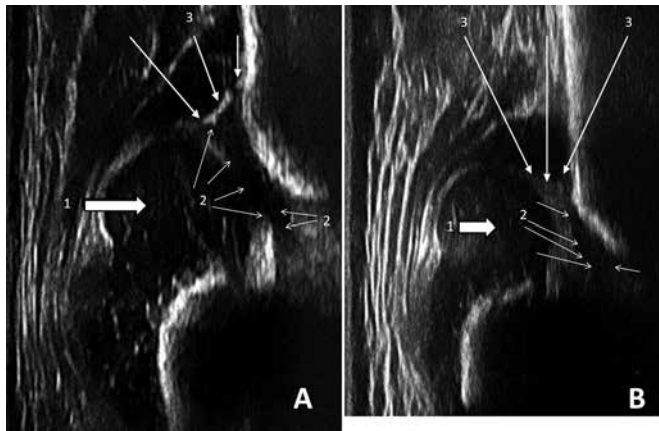


Fig. 2 - Sonograms showing displaced femoral heads (1) the deformed hyaline cartilage roof is marked (2) as well as the perichondrium (3). (A) Type III, (B) Type IV.

Where is the labrum? Where is the deformed cartilaginous roof? How much is it deformed? (Fig. 2A, B). This knowledge is fundamental for standardised evidence based not just on experience but based on treatment appropriate to the biomechanical situation, i.e. sonographic type, needs reduction? Which retention? Which maturation? (10).

- To classify according to age.
The development of the baby hip joint is very rapid in the first weeks of life so what is acceptable at what age? The proportions of the bony and cartilaginous roof acceptable for a baby aged 4 weeks, are not acceptable for a 4-month-old (Sonographically type IIa/ IIb) (Fig. 3) (9, 10).

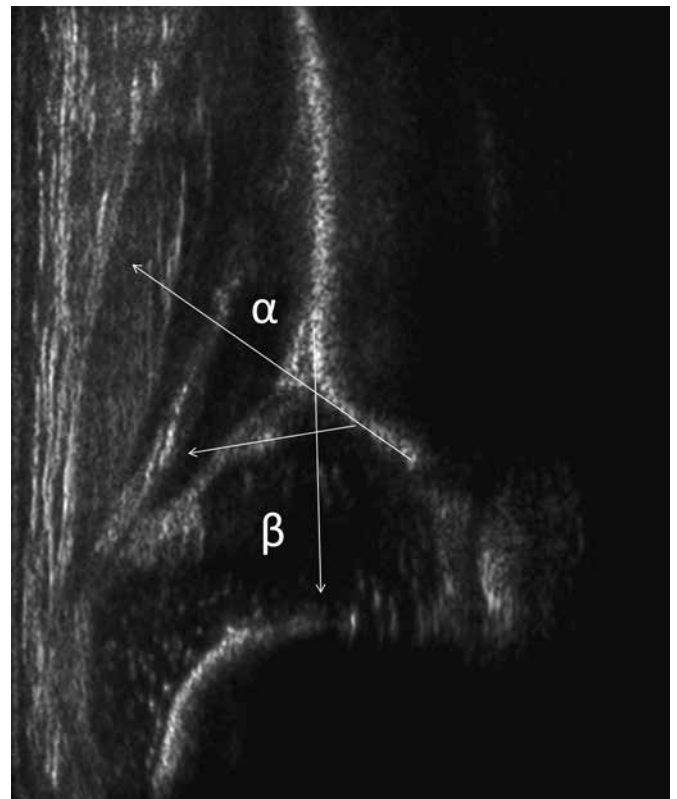


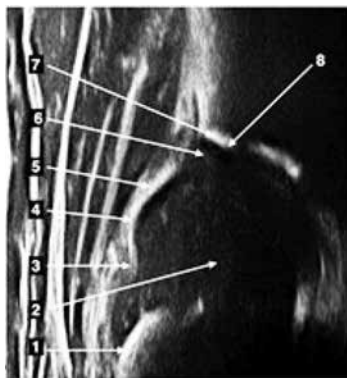
Fig. 3 - Alpha 55°, Beta 80°: Acceptable for 4 weeks, (Type IIa) "normal according to the age". In a 4-month-old a dysplastic joint which needs treatment, (Type IIb).

Technique and common mistakes

Sonograms must be reproducible and comparable. Different sectional planes, whether anterior, in the middle, or posterior on the bony roof give different measurements. To make sonograms reproducible only the 'standard plane' is allowed to be used for diagnosis (only 1 exception: in decentered hips) (7).

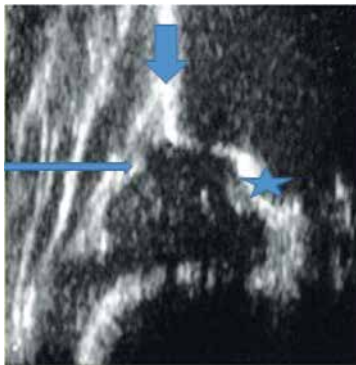
Technique

- Standardised examination technique with appropriate equipment.
- Anatomical identification (Checklist I) always first (Fig. 4). If even one of the points cannot be identified, the sonogram should not be accepted for a diagnosis.
- Usability check (Checklist II) (Figs. 5 and 6).
- Classification of 4 basic types and subtypes related to management
- Measurement only on scans in the standard plane with diagnosis by objective measurement and not by guesswork.
- Diagnosis is made by measurement (objective evidence) and is not dependent on the position of the femoral head. It takes into account the pathoanatomical situation inside the joint and the age of the patient.
- Separation of pathological movements (instability) from harmless movements (elastic whipping) is possible. Hip



1. Chondroosseous border
2. Femoral Head
3. Synovial fold
4. Joint Capsule
5. Labrum
6. Cartilage
7. Bony roof
8. Bony rim (turning point)

Fig. 4 - Checklist I: Anatomical identification. If even 1 of the points cannot be identified, the sonogram should not be used for a diagnosis.



- Lower limb of os ilium
- Plane
- Labrum

Fig. 5 - Checklist II: A plane needs 3 landmarks: (1) the lower limb of os ilium; (2) the middle of the bony roof; (3) the labrum.

sonography is always “dynamic”, because a tomogram is made. However, to make it reproducible only a standard plane is used for diagnosis. In borderline cases an additional “stress test” is made to decide whether the joint is stable or unstable. This decision is therefore made by objective measurement and not by subjective “feeling” (Type IIc-stable or type IIc-unstable) (8, 9).

Mistakes

All the typical mistakes that can be made can be well known and can be listed (15):

- Incorrect anatomical identification e.g. labrum mixed up with synovial fold or perichondrium, cartilaginous roof not identified, joint capsule confused with intermuscular septum, etc. Research has shown that most of the errors made in ultrasound diagnosis are due to incorrect anatomical identification (15).
- When the exception that a decentered hip can be diagnosed without the standard plane is not known, especially when combined with errors in anatomical identification, displacement can be misdiagnosed as a “normal” hip joint (15).

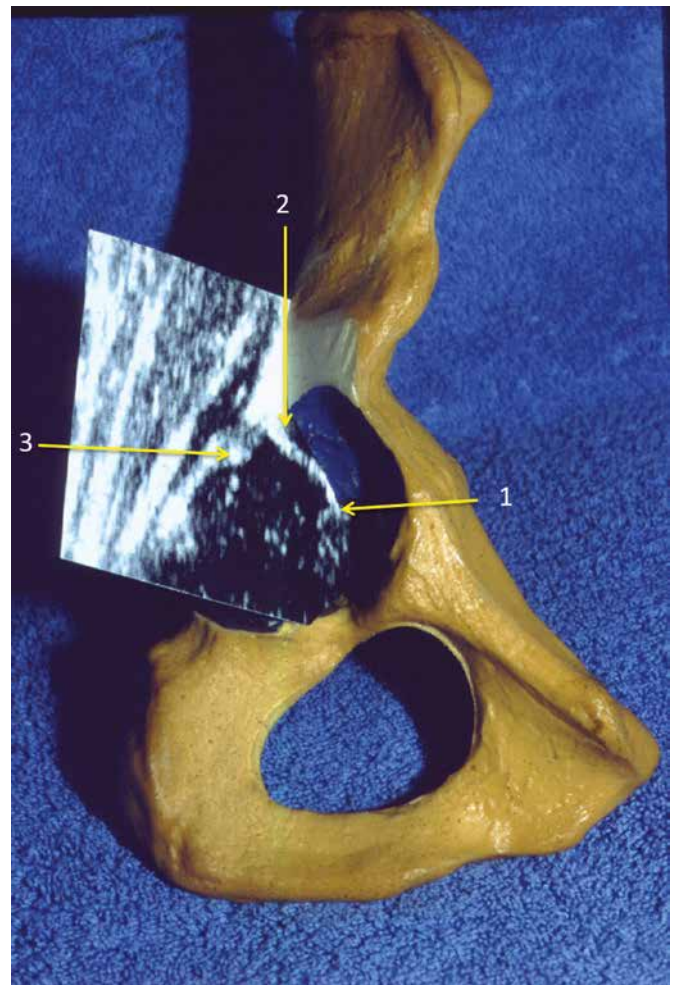


Fig. 6 - 3-D orientation of the standard-plane: the 3 landmarks are marked with arrows (see Fig. 5).

- Sector or trapezoid probes lead to over diagnosis because of the differing speeds of ultrasound in cartilage, bone and soft tissue, the ultrasound beam is bent and refracted so only linear probes are allowed to be used.
- Tilting effects also lead to over diagnosis for the same reason. Free hand scanning without a probe guide system to prevent tilting should be history! (Fig. 7).

Results

Examples of results of general or targeted screening (Tab. I) (11-13, 16, 17) in countries, where the “Graf-technique” is used show:

- Open reductions dramatically reduced.
- Acetabuloplasties and head necrosis reduced.
- Costs for screening and costs for treatment are 33% cheaper than the treatment costs alone before the screening programs started (10).
- Conservative treatment rate also reduced, because treatment is now according to sonographic evidence and not by subjective clinical examination.

- Babies older than 6 weeks with a dislocation are late cases (18).
- End of treatment with healthy joints before babies start walking.



Fig. 7 - Scanning with cradle, probe guide system and linear probe to avoid the tilting effects that can cause misdiagnosis.

Debate and politics

Medical services differ in all countries throughout the world. Many countries realise that improvement of the general health of the population is only possible with more prevention (e.g. mammography and vaccination) rather than with operations (10-13). Diagnosis should be as early as possible, without harming patients and ideally with low costs.

The debate about hip sonography screening has the following background: different techniques and 'modifications' have been described raising questions about the reliability of ultrasound. Diagnostic techniques and measurements, which take the size of the femoral head into account or measure the bony roof in relation to the head cannot work because the femoral head in a baby hip joint is not round. Likewise, those that do not take the age into account, these techniques are history and are strictly forbidden in the "screening countries".

All that is written about or described as "hip sonography" is not diagnostic hip sonography! It is better to do nothing, than to do sonography as we did it 30 years ago (2, 6). This is the reason that in some countries only the "Graf-technique" is allowed and paid for by the health insurance systems (11-13, 16).

Misinformation comments are often heard, "the Graf-technique is so complicated, so many types, so difficult to find the standard plane". The answer is that today we have achieved a very high standard using a systematically developed straightforward method.

Today's standard of hip sonography has been achieved by ongoing development during the last 30 years and for 25 years has been used for screening in many countries.

We have a tool in our hands with which we can see all the anatomical structures in seconds without radiation.

We have learned the dynamics of dislocation and the pathological deformities. We have stopped some confusing historical terms e.g. "limbus, inverted limbus, inverted labrum" (19).

Organisation

The organisation of screening is also political:

- When should it be done?
Based on the maturation curve (20) of the joint it should be done within the window up to the beginning of the 6th week.

TABLE I - Examples of the effectiveness of universal or targeted

| Author | Year | Journal | Location | Facts |
|-------------------|------|--|------------|---|
| Thaler et al (24) | 2011 | The Journal of Bone and Joint Surgery (Br) | Austria | (1978-1982 -> 1993-1997) ↓ Cost reduction.....-72% ↓ Rate of splintage.....-48% ↓ Surgical procedures.....- 85% ↓ Hip reductions.....-73% |
| Gray et al (25) | 2005 | The Journal of Bone and Joint Surgery (Am) | UK/Ireland | ↓ Splinting costs.....-22% ↓ Surgery costs.....-8% ↓ Costs per patient.....-13% |

Screening compared with clinical examination alone.

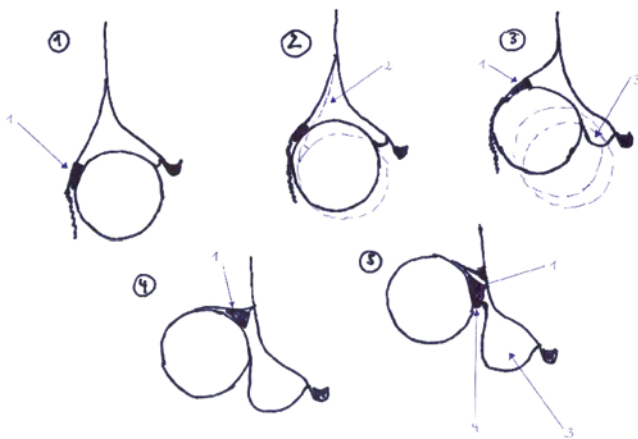


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Fig. 8 - Developmental dislocation: (1) The hyaline cartilaginous roof is not ossified enough and is deformable, Labrum 1); (2) The head presses the cartilaginous roof (CR) cranially; (3) The CR is deformed, most of the CR is pressed upwards, only a little bit is pressed downwards 3); (4) All of the CR is pressed downwards and blocks the reduction; (5) The labrum is never “inverted”, only the base 4) is pressed down. Labrum 1) downward pressed cartilaginous roof 3).

- Who should do the examination?
Anyone who has undergone appropriate training by authorised teachers and been granted a certificate (21); (no bedside teaching!) (16). Most commonly orthopaedic surgeons, radiologists, paediatricians and sonographers.

Challenges

- To convince everyone to do hip sonography using the correct technique without modifications (because all the mistakes that can be done have already been done). It is better to do nothing than to do it incorrectly (22).
- To convince everyone that the purpose of hip sonography is not only to see whether the femoral head is inside the acetabulum or not. This was the standard of 1980 (2). The dislocation develops (Fig. 8) so the joints must be checked as early as possible to detect the borderline cases before the head is completely dislocated (18).
- To establish protocols and quality management as practiced in countries where Ultrasound screening is already established.
- To impress on the examiner to accept for diagnosis only sonograms that have passed Checklist I and Checklist II.
- To make it clear, that neither the clinical examination, nor checking only ‘at risk’ babies, can solve the problem. The facts (1, 12, 22, 23) are so often ignored.
- When hip sonography is discussed always first ask the question: “What technique?” as all “hip sonography” is not hip sonography!

Disclosures

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