"ICODE Hip US Calculator": a mobile phone aid for screening with Graf's sonographic technique

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Abstract

Aim: Aiming to offer a diagnostic tool to aid examiners with correct hip typing and decision-making about patient management, members of the Board of the International Interdisciplinary Consensus Committee on DDH Evaluation (ICODE – https://www.icode.expert), introduced the cross-platform mobile application (Android and iOS) called "ICODE Hip US Calculator". **Material and methods:** The examination steps of Graf's hip sonography technique were converted into computer code and formed the basis for the development of a mobile phone application. An algorithmic approach, based on a series of conditional sentences, was followed for the development of the application (e.g. if … and … or … then). Coding of the algorithm was carried out by a Greek software development company. **Results:** A cross-platform mobile phone application which calculates Graf's hip type (according to the date of birth, the date of examination, and the alpha and beta angles) was constructed. The calculated hip type is then linked to simple management recommendations (discharge, rescan, refer). **Conclusions:** "ICODE Hip US Calculator" may be used by trained health professionals to help them decide upon the hip type and the management of the baby after the scan. Hip typing is precisely calculated, and management proposals are simple and straightforward. This means that the application may be used in screening settings to help with patient management, increase the examiner's confidence, and improve patient flow.

Introduction

The introduction of hip ultrasonography by Reinhard Graf in 1980[1] has changed the natural history of developmental dysplasia of the hip (DDH) by making early diagnosis and conservative treatment feasible during the first weeks/months of life. Universal DDH screening was introduced many years ago in Germany, Austria and Switzerland, and in parts of Italy, but only very recently in Mongolia[2–5]. It is expected that the promotion of Graf's technique, which is based on the successes in the above-mentioned geographic areas, will sooner or later result in the introduction of universal sonographic screening.

Graf's technique consists of very specific steps, which must be followed meticulously. For this reason, structured training and reporting is necessary, and thorough understanding of the principles and the classification/typing system is mandatory. The same applies to guidance for referral for treatment based on hip type[6].

Aiming to offer a diagnostic tool to aid examiners with correct hip typing and decision-making about patient management, members of the Board of the International Interdisciplinary Consensus Committee on DDH Evaluation (ICODE –https://www.icode.expert) introduced the cross-platform mobile application (Android and iOS) called "ICODE Hip US Calculator".

Materials and methods

Diagnostic typing according to Graf's technique is based on the measurement of the angles (alpha and beta) and their relationship with age, when required. The alpha angle defines the hip type in Types I (mature hips), III & IV (decentered hips). The most complex diagnostic zone is the Type II/D zone, especially the range from 50° to 59°, in which the baby's age is a deciding factor. Management options are related to hip type[6].

The above-mentioned information was converted into computer code and formed the basis for the development of the application. An algorithmic approach, based on a series of conditional sentences, was followed for the development of the application (e.g. if … and … or … then). Coding of the algorithm was carried out by iservices (https://iservices.gr/), a Greek software development company.

Results

A cross-platform mobile phone application which calculates Graf's hip type (according to the date of birth, the date of examination, and the alpha and beta angles) was constructed.

At installation of the application, a disclaimer which summarizes the legal restrictions and the conditions of use is presented to the user, who is then asked to accept it as an absolute prerequisite for safe use of the application (Fig. 1). Basic literature references are listed at the bottom of the disclaimer page[6–8].
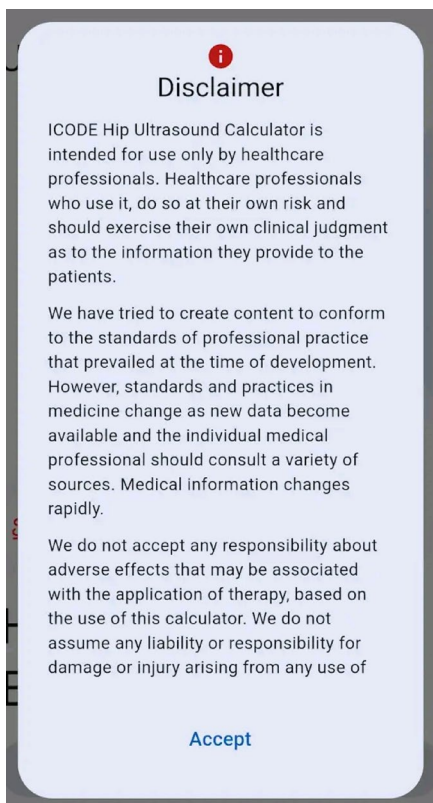

Fig. 1. *At installation, a disclaimer summarizing the legal restrictions and the conditions of use is presented to the user, who is then asked to accept it as an absolute prerequisite for safe use of the application*
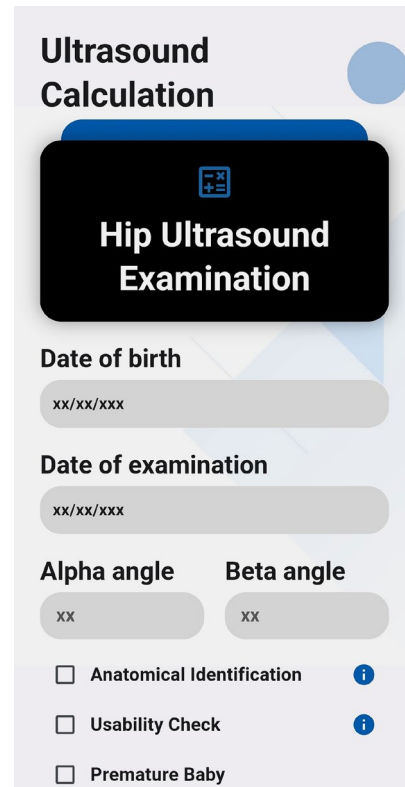

Fig. 2. *Main screen of the application. In addition to entering the date of birth, the date of the examination, and the angles, the user is required to confirm completion of the quality control procedures (anatomical identification and usability check) in order to proceed with the calculation*

After entering the data required for hip type calculation (see below), to continue with the diagnostic procedure, the user is required to tick the checkboxes referring to the Checklists 1 & 2, thus confirming that quality evaluation has been performed, and the image is usable. In the event that help is needed with the Checklists, pressing the (i) button, will open a new window, which presents the main components of the two checklists (Fig. 2).

This page also includes a checkbox for indicating prematurity. By selecting this option, the user confirms awareness of the recommendations about hip typing and treatment in premature neonates/infants (Fig. 3).

Data required for the calculation of hip type include (1) the date of birth, (2) the date of examination (as a default, the current date is set), (3) the alpha angle, and (4) the beta angle. The age of the baby is calculated by subtracting the date of birth from the date of examination.

After pressing the "Calculate" button, the user is presented with (a) the final hip type, and (b) recommendations for management (examples of different hip types are shown in Fig. 4, Fig. 5, Fig. 6, and Fig. 7). Due to the fact that a wide range of personnel may use this tool, the final diagnosis is linked to simple management recommendations (discharge, rescan, refer).

The hip types calculated by the application are Types I, II (IIa, IIa+ & IIa−, IIc), D, III and IV.
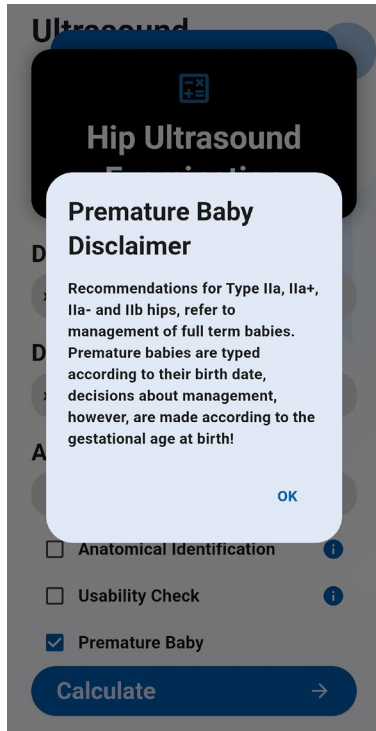
Fig. 3. *Disclaimer for prematurity presented after checking the Premature Baby checkbox*
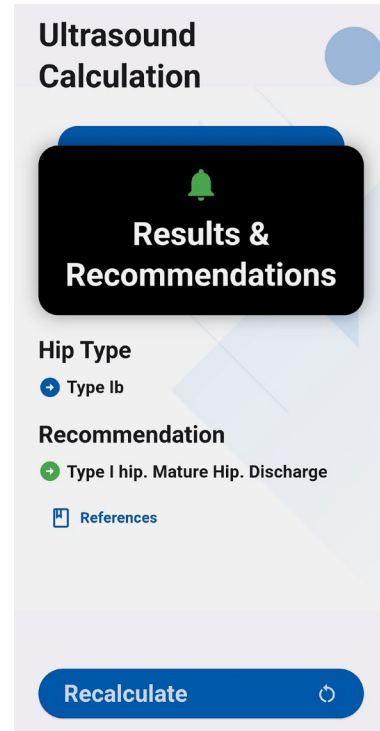

Fig. 4. *Example of results for Type I hip. No further actions are recommended. There is a link to the theoretical information (References) upon which calculations and recommendations are based*
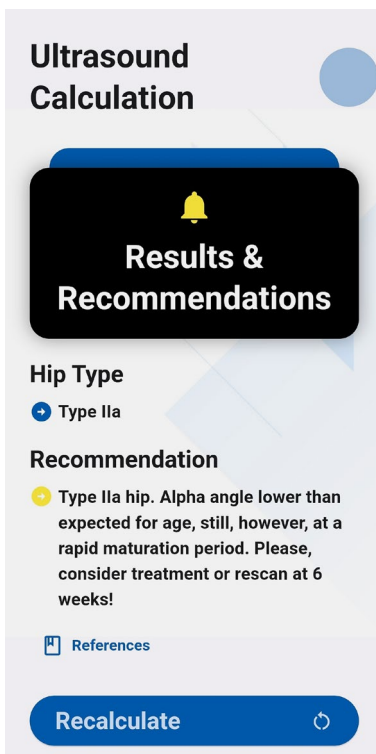

Fig. 5. *Example of results for Type IIa hip of a baby younger than 6 weeks, with an angle estimated as lower than expected for age. In this case, the examiner is advised to rescan at 6 weeks or initiate treatment. There is a link to the theoretical information (References) upon which calculations and recommendations are based*
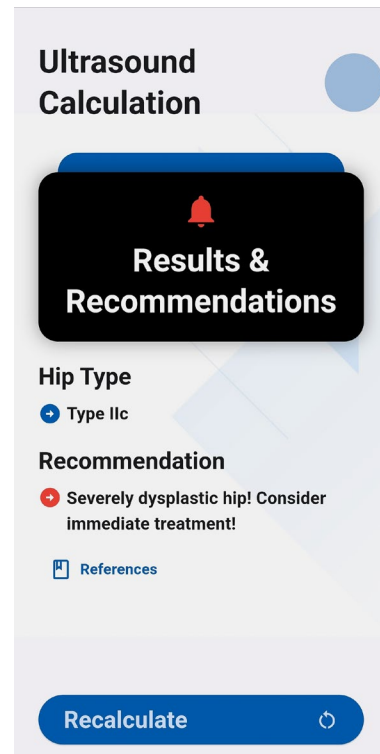

Fig. 6. *Example of results for Type IIc hip (severely dysplastic). Regardless of age, the examiner is advised to consider immediate treatment. There is a link to the theoretical information (References) upon which calculations and recommendations are based*

Fig. 7. *Example of results for Type III or IV hip (depending on the position of the hyaline cartilage). Regardless of age, the examiner is advised to consider immediate treatment. There is a link to the theoretical information (References) upon which calculations and recommendations are based*
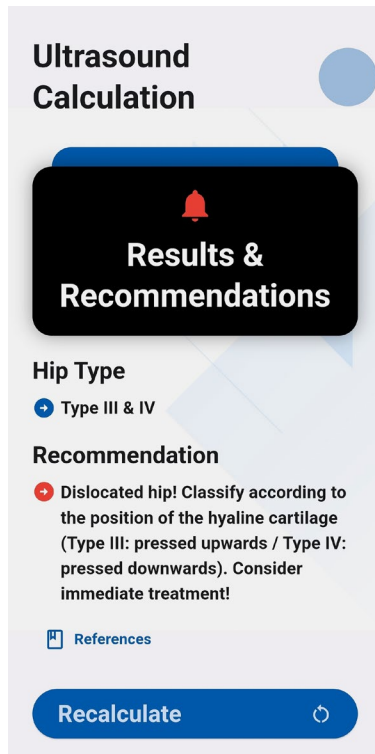

Fig. 8. *Summary of the main advantages of the ICODE Hip US Calculator, as presented in London on June 8 and 9, 2023, during the ICODE International Meeting*

Recommendations for management are as follows:
- Type I hip. Mature Hip. Discharge. (Type I Hip).
- Type IIa hip. Immature hip. Please rescan at 6 weeks! (Depending on age, Type IIa Hips).
- Alpha angle lower than expected for age, but still in a period of rapid maturation. Please consider treatment or rescan at 6 weeks! (Depending on age, Type IIa Hips).
- Physiologically immature hip. Please follow up every 3 to 4 weeks until the alpha angle is ≥60°. Restage according to baby's age at every scan. (Type IIa+ Hips).
- Delayed ossification of the cartilaginous roof. Please consider treatment! (Type IIa- Hips).

- Dysplastic hip! Please consider treatment! (Type IIb Hips).
- Severely dysplastic hip! Consider immediate treatment! (Type IIc Hips).
- Severely dysplastic/dislocating hip! Consider immediate treatment! (Type D Hips).
- Dislocated hip! Classify according to the position of the hyaline cartilage (Type III: pressed upwards / Type IV: pressed downwards). Consider immediate treatment! (Type III & IV Hips).

It is clear that this application is a calculator and not a database, which means that the result is anonymous, and not stored. Patient data are not required, so patient anonymity is preserved. Importantly, it is strongly advised that only health professionals who are trained and licensed to perform and/or report Graf's hip sonography examinations should use the application (as clearly stated in the disclaimer).

Discussion

Smartphones and mobile devices have become part of everyday life. They have replaced several tools which in the past formed the basis for professional practice, including calendars and calculators. Mobile apps are distributed through a worldwide marketplace network, with the most important representatives being Google Play Store (Android – https://play.google.com/) and App Store (iOS – https://www.apple.com/app-store/), two sales networks with millions of customers, all over the globe. It is inevitable that everyday medical practice will benefit from the technological evolution of mobile power by developing and distributing medical applications via the above-mentioned platforms[9,10].

Graf's technique has long been widely used for the diagnostic evaluation and treatment monitoring of DDH[7]. The main benefit of Graf's technique is the fact that it has been thoroughly described, and extensively tested and verified[11–13]. However, its very detailed nature, which is due to the complex pathophysiology of the disorder, is perceived by some examiners as a disadvantage of the technique, a source of confusion, and a reason for suboptimal performance (including "overtreatment")[12,14–16]. It has been suggested that this perceived "complexity" is one of the main reasons why the technique has not been widely implemented in certain countries[17].

Graf's sonographic technique can be schematically divided into three main phases:
(a) examination technique, quality evaluation, and measurement of angles;
(b) typing/classification;
(c) clinical management.

This mobile application aids with phases (b) and (c). It may be used by trained health professionals to help them determine hip type and management of the baby after the scan. Hip typing is precisely calculated, and management proposals are simple and straightforward. This means, of course, that the application may be used in screening settings to help with the management of patients, to increase the sonographer's confidence, and to improve patient flow. The main advantages of the calculator are summarized in Fig. 8 (as presented at the ICODE International Meeting in London on June 8 and 9, 2023, by Dr. Konstantinos Chlapoutakis and Dr. Claudia Maizen).
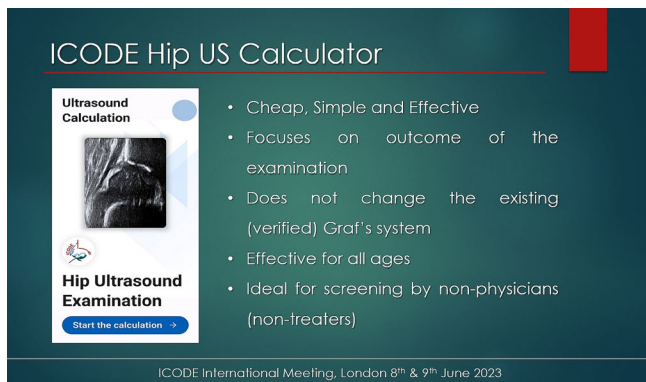
A limitation of the calculation algorithm is the fact that the slope of the maturation curve of the hip joint during the first few weeks of life is steeper, so our calculations may underestimate the growth potential of the hip joint in this age group, thus leading to unnecessary reexaminations during the age window between birth and 6 weeks of age (when rescans would be an option anyway)[6]. On the other hand, the calculations of the algorithm which is utilized to "simulate" the growth curve of the hip (developed by Dr Beat Dubs) are safe for all age groups without causing overtreatment. The algorithm may, of course, be updated if scientific data change significantly, suggesting revision of the mathematical formula utilized.

With Graf's technique, it is important to acquire a "standard plane" section, decide if the hip is centered or not, identify the anatomic structures, and measure the angles correctly. Therefore, robust training is necessary. Such training is in fact, carried out in international courses that take place periodically in several countries. On the other hand, as long as the above-mentioned steps have been completed, correct determination of hip type is a procedure which may be aided by the use of simple computer or mobile phone software. This makes diagnosis and management an easily achievable target and, at the same time, minimizes confusion that can result in misclassification and, consequently, treatment errors.

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Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Author contributions

Original concept of study: KC, JO, BD, CM, SP. Writing of manuscript: KC, JO, BD, CM, SP, CC. Analysis and interpretation of data: KC, BD. Final acceptation of manuscript: KC, JO, CM, SP, TT, CC. Collection, recording and/or compilation of data: KC, BD, CM. Critical review of manuscript: KC, JO, CM, SP, TT, CC.

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