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Standardisation of crown–rump length measurement

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Correct estimation of gestational age is essential for any study of ultrasound biometry and for everyday clinical practice. However, inconsistency in pregnancy dating may occur through differences in measurement methods or errors during measurement. In the INTERGROWTH-21st Project, pregnancies are dated by the last menstrual period, provided that it is certain and associated with a regular menstrual cycle, and the gestational age by dates concurs with a first-trimester ultrasound crown–rump length (CRL) estimation. Hence, there was a need to standardise CRL measurement methodology across the study sites in this international, multicentre project to avoid systematic differences in dating. To achieve uniformity we undertook the following steps: the ultrasound technique was standardised by disseminating an illustrated, operating manual describing CRL plane landmarks and calliper application, and posters describing the correct acquisition technique were disseminated for quick reference. To ensure that all ultrasonographers understood the methodology, they forwarded a log-book to the INTERGROWTH-21st Ultrasound Coordinating Unit, containing the answers to a written test on the manual material and five images of a correctly acquired CRL. Interpretation of CRL was also standardised by ensuring that the same CRL regression formula was used across all study sites. These methods should minimise potential systematic errors in dating associated with pooling data from different health institutions, and represent a model for standardising CRL measurement in future studies.

Keywords Crown–rump length, dating, gestation, growth, pregnancy, ultrasound.

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Introduction

The International Fetal and Newborn Growth Consortium for the 21st Century (INTERGROWTH-21st) is a large-scale, population-based, multicentre project involving health institutions from eight geographically diverse countries, which aims to assess fetal, newborn and preterm growth under optimal conditions, in a manner similar to that adopted by the World Health Organization (WHO) Multicentre Growth Reference Study (MGRS).[1] The INTERGROWTH-21st Project has three major components, which were designed to create: (1) longitudinally derived, prescriptive, international, fetal growth standards using both clinical and ultrasound measures; (2) preterm, postnatal growth standards for those infants born at $\geq 26^{+0}$ but $< 37^{+0}$ weeks of gestation in the longitudinal cohort, and (3) birthweight-for-gestational-age standards derived from all newborns delivering at the study sites over an approximately 12 month period.[2]

In every pregnancy contributing data to the development of growth standards, it is essential to ensure that gestational age is estimated accurately. Other than counting from the first day of the last menstrual period, the principal methods used to date a pregnancy are ultrasound measurement of the fetal crown–rump length (CRL) in the first trimester[3,4] or the biparietal diameter,[6] head circumference,[4] femur length[4] or transcerebellar diameter[5] in the second trimester. In routine clinical practice, more than one of these methods may be used, leading not uncommonly to changes in the estimated date of delivery in individual pregnancies. In a research context, such a lack of consistency can introduce random and systematic bias, especially if women are being recruited in many different health institutions that do not have a uniform policy regarding gestational age estimation.

To achieve uniformity in the longitudinal component of the INTERGROWTH-21st Project—the Fetal Growth Longitudinal Study (FGLS)—the last menstrual period was used to calculate gestational age provided that: (1) the date was certain; (2) the woman had a regular 24–32 day menstrual cycle; (3) she had not been using hormonal contraception or breastfeeding in the preceding 2 months,

and (4) any discrepancy between the gestational ages based on last menstrual period and CRL, measured at 9^{+0} to 13^{+6} weeks from the first day of the last menstrual period, was $\leq$7 days (see Table 1 which summarises the criteria).

This paper describes the procedures that were employed by the INTERGROWTH-21st Ultrasound Coordinating Unit to standardise ultrasound dating of pregnancy across the study sites. In brief, this involved ensuring that all the ultrasonographers were familiar with the FGLS protocol, and that they adhered to standard methods for obtaining the CRL measurement and converting its value into a gestational age.

Methods

Each ultrasonographer involved in ultrasound dating of eligible women at the sites participating in FGLS was given a 15-page, illustrated, operating manual entitled *Correct measurement of fetal crown–rump length and standardisation of ultrasonographers* (see Supporting information, Appendix S1).

The first part of the manual (pp. 1–10) contains the INTERGROWTH-21st dating criteria (Table 1) and is followed by a step-by-step method for correct generation of a CRL imaging plane and calliper application (Figure 1). In addition, there are practical examples of incorrect CRL images to highlight common errors (Figure 2). At the end of the manual is a 'Common Questions' section containing questions and answers relating to a range of pregnancy dating scenarios.

The second part of the manual (pp. 11–15) is a personal logbook. All ultrasonographers were asked to: (1) acknowledge that they had read the manual; (2) complete a short test consisting of eight multiple choice questions, and (3) forward five images of correctly acquired CRL measurements from their own practice. Image review was performed independently of the Ultrasound Coordinating Unit, and blinded to the ultrasonographer's identity or his/her short-test results. The image review was provided by the Société Française pour l'Amélioration des Pratiques Echographiques after uploading the images to the relevant website (www.sfape.com). A certificate of completion was issued if all the answers were correct and the images were of satisfactory quality.

A quick reference, single-page poster was also sent out to the participating sites (see Supporting Information, Appendix S2) as a reminder of the correct plane acquisition and calliper placement for reliable CRL measurement.

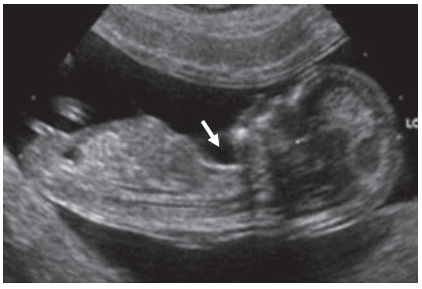
A single ultrasound machine (Philips HD-9; Philips Ultrasound, Bothell, WA, USA), which was used across all study sites for biometric measurements ($> 14^{+0}$ weeks of gestation) in FGLS, was the machine of choice to measure CRL ($< 14^{+0}$ weeks of gestation). The default setting on this machine to convert CRL values to gestational age was the formula described by Robinson and Fleming.[7] However, it was also acceptable to use other, locally available, ultrasound machines to measure CRL in women eligible for FGLS; for that purpose, each study site was provided with a printed Robinson conversion table.

Table 1. Inclusion criteria in the FGLS to ensure accurate determination of gestational age

Certain last menstrual period
Regular 24–32-day menstrual cycles
No hormonal contraception use or breastfeeding in the preceding 2 months
Spontaneous conception
CRL measurement between 9^{+0} and 13^{+6} weeks of gestation
Discrepancy between CRL and last menstrual period estimates $\leq$ 7 days

Discussion

Measurement of CRL is the method of choice for ultrasound assessment of gestational age in the first trimester,[8] but it is susceptible to intra-observer and inter-observer variation. This may result from inconsistent or incorrect acquisition of the appropriate images. For example, a parasagittal plane may not contain the entire fetal length, leading to CRL



Good magnification
The fetus fills almost the entire screen.

Mid-sagittal section
The profile, spine and rump are visible.

Neutral position
There is fluid visible between the chin and the chest of the fetus (see arrow).

Fetus is horizontal
Almost 90° to the ultrasound beam

Crown and rump are clearly seen

Callipers are placed correctly
The intersection of the callipers should be placed on the outer borders of the skin over the head and rump.

Figure 1. Features of a correct CRL measurement..

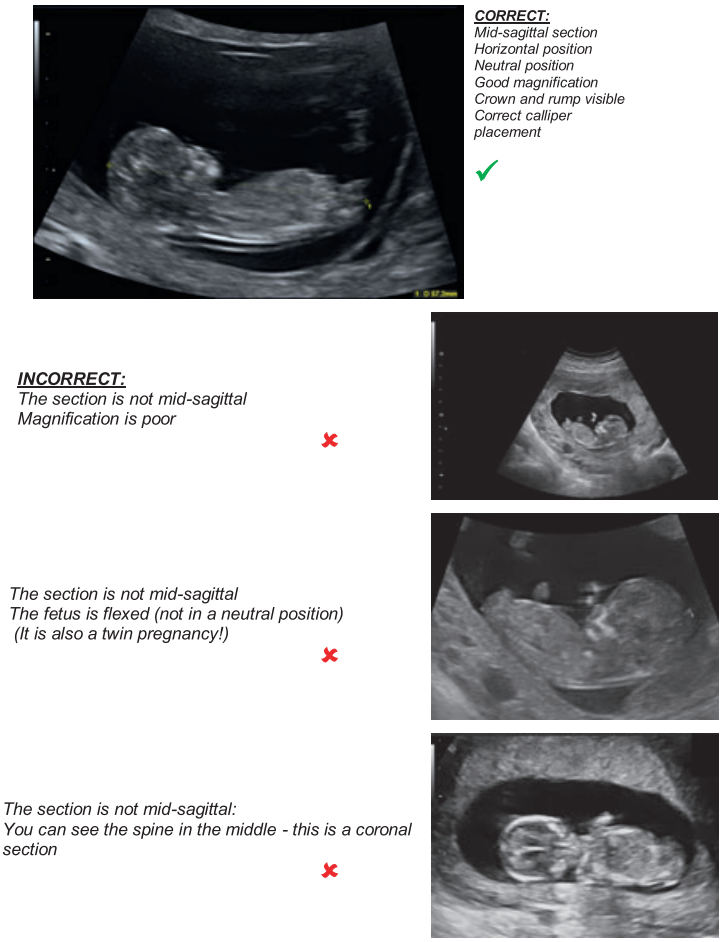


Figure 2. Examples of correct and incorrect CRL measurement.

underestimation; conversely, a hyper-extended fetal neck will lead to CRL overestimation. Incorrect positioning of the callipers will also produce inaccurate measurements.

In a large-scale, multicentre project such as INTERGROWTH-21st, it is essential to introduce and implement standardisation protocols from the outset to ensure that measurements are taken accurately and reliably. Towards that end, we produced an illustrated reference manual and a poster for the examination room as useful reminders of best practice. In addition, we introduced a personal log-book for the ultrasonographers as a simple means of assessing their understanding of the CRL protocol and the adequacy of their technique by auditing five printed images of CRL measurements. Prior research has shown that the use of image quality scores is a simple and reproducible tool,[8] which can improve the consistency of scanning.[9]

The other major source of inconsistency is the interpretation of CRL measurements, i.e. the conversion of a CRL measurement into a gestational age or estimated date of delivery, which is generally achieved by software within the ultrasound machine or by reference to a printed table. However, these conversion methods rely on different CRL regression equations: in fact, at least 21 equations have been reported in the literature to date.[3] The use of different formulae can lead to a systematic estimated date of delivery discrepancy of up to 4 days,[3] hence the need for a single CRL regression equation across study sites. This was achieved by loading only the Robinson equation into the INTERGROWTH-21st ultrasound machines or by providing a conversion table extracted from the same equation, whenever another machine had to be used locally.

Pregnancy dating practices in large health institutions across the world often differ[10] or are not in agreement with our method of gestational age assessment. It could, therefore, be argued that the prescriptive protocol we adopted in the INTERGROWTH-21st Project may limit the external validity of our findings. Although this is true in principle, we feel that, in a project of this magnitude, which aims to generate international growth standards, every effort should be made to standardise the operating procedures, and describe them openly to allow critical appraisal. Clearly, those health institutions that choose to adopt the INTERGROWTH-21st

standards in their clinical practice would be strongly advised to use this dating convention.

In summary, we have described a number of factors that introduce heterogeneity into gestational age estimation and highlighted operational procedures to improve the consistency of CRL measurement and the accuracy of interpretation in the context of a large, international study of fetal biometry.

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Disclosure of interests

Philips HD-9 Ultrasound machines and technical assistance were provided by Philips Health Care. Philips representatives paid for meals at meetings with Dr Aris Papageorghiou.

Contribution to authorship

C Ioannou drafted the manuscript and all the authors read and approved the final version.

Details of ethics approval

The INTERGROWTH-21st Project was approved by the Oxfordshire Research Ethics Committee 'C' (reference: 08/H0606/139), and the research ethics committees of the individual participating institutions and corresponding health authorities where the Project was implemented.

Acknowledgements

A full list of members of the International Fetal and Newborn Growth Consortium for the 21st Century (INTERGROWTH-21st) and its committees appears within the preliminary pages of this supplement.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. INTERGROWTH-21st Project CRL standardisation; reprinted with permission from the University of Oxford.

Appendix S2. CRL. Key points on accurate measurement. ■

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