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# A New Approach in Detectability of Microcalcifications in the Placenta During Pregnancy Using Ultrasonographic Image Enhancement Techniques

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**Abstract**

**Background and Objectives:** Placenta, the only organ in the body derived from two separate individuals, is a dynamic structure that ensures normal foetal development. Ultrasonographic evaluation of placenta during pregnancy shows a progressive transformation, many of these changes being considered as normal aspects of aging and maturation. In this respect, placental calcification commonly increases with gestational age, and becomes apparent after 36 weeks of gestation. Before this gestational age, excessive placental calcification, commonly named preterm placental calcification, is a predictor of poor uteroplacental flow and is associated with poor maternal and foetal outcome. These cases could benefit from an early detection of placental calcifications so that closer foetal and maternal surveillance could be achieved.

**Materials and Methods:** Although ultrasound scanner systems for medical imaging applications can provide good results, there are still various sources of interferences and other phenomena that are affecting the medical images. Consequently, the image under investigation and the procedures used in imaging may diminish the contrast and the visibility of details. In this context we propose a newly adapted approach based on improving the details clarity, aimed to increase the detectability of microcalcifications in ultrasonographic evaluation of placenta during pregnancy.

**Result:** Experimental results carried out on real clinical data show that the proposed approach allows a significantly improved visibility and detectability of less obvious microcalcifications when compared with standard ultrasound images.

**Conclusion:** The newly developed clinical task is intended to be used together with other medical procedures and software, particularly in high risk pregnancies.

**Keywords:** Placenta; Calcifications; Preterm placental calcification; Image enhancement techniques

## Introduction

Placenta is a very dynamic organ whose morphological and functional integrity is the key factor for a normal developing foetus. Ultrasonographic appearance of the placenta is very much dependent on gestational age. Different aspects are normally seen in different weeks of gestation. According to well-known ultrasound Grannum classification there are 4 different grades of placental evolution during pregnancy. In grade 0 the placenta has a uniform echogenicity and a smooth chorionic plate whereas in grade III the extensive calcium deposits resemble deep indentations and ring-like structures. A representative example of placental evolution during pregnancy can be seen in zoomed format in figure 1.

Placental calcifications are often mentioned on ultrasound examination during pregnancy and seen as echogenic foci as the calcium is progressively deposed in the placental tissue [1]. Placental calcification is usually thought to represent a physiological process, a normal feature of aging and maturation [2]. Reports in the literature have shown that more than 50% of placentae had some degree of calcification and at least 18% showed excessive calcification [3]. Miller et al reported that grade III placental calcification was found in 39.4% of pregnant women at term [4].

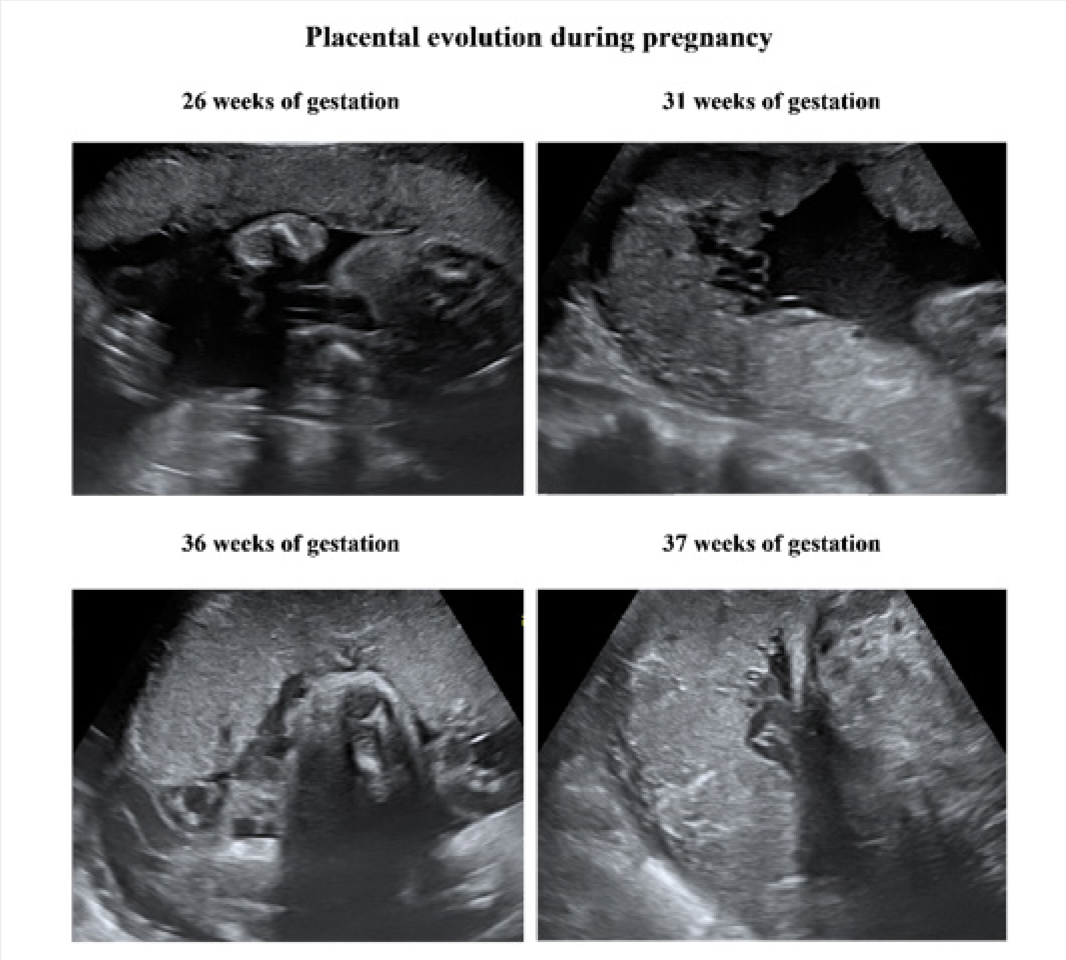


**Figure 1:** Ultrasonographic appearance of the placenta between 26 and 37 weeks of gestation.

In most of the pregnancies, minor placental calcifications are found late in gestation and are considered a marker of tissue aging. However certain behaviour or medical conditions of pregnant women, such as cigarette smoking, exposure to radiation or low frequency sound, medications such as antacids or vitamin supplements with excessive calcium, pregnancy induced hypertension, placental abruption, infections are associated with excessive placental calcification [5].

When placental calcification becomes evident before 36 weeks of gestation, it is considered to be preterm placental calcification [2]. In addition, placental calcifications seen before 32 weeks of gestation are called early preterm placental calcifications and those noticed between 32 and 36 weeks of gestation are called late preterm placental calcifications. The prevalence of preterm placental calcification has been reported as 3.8% (measured only at 36 weeks) [6]; 9% before 28 weeks [7]; 15% between 34 and 36 weeks of gestation [8] and 23.7% between 31 and 34 weeks [9].

Although there are some reports in the literature that state that placental calcifications during pregnancy have no effect whatsoever on foetal development and prognosis, many other studies have associated preterm placental calcifications with poor foetal outcome. According to these reports, preterm placental calcifications are associated with increased risk of intrauterine growth restriction [6,9], low birth weight [6,8-10], low Apgar score [8], neonatal death [1], pregnancy-induced hypertension [6,11], placental abruption and postpartum haemorrhage [1]. Moreover, after Chen et al, isolated early preterm calcifications, e.g. calcifications seen before 32 weeks of gestation, are independent risk factors of poor outcome for both mother and foetus [1]. These cases should require proper counselling and close surveillance.

In respect with these findings, placental calcification should be regarded not only as a usual aging process, but also as a possible placental dysfunction especially when it is noted in earlier stages of pregnancy. During the recent years, the collaboration between


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clinicians and engineers has had a tremendous impact on the field of medical imaging. The medical professionals are interested in exploring new methods for improving manual interpretation and analysis of medical images which are complex and prone to error because some details cannot be very clearly interpreted and occasionally this result in misdiagnosis. In this context, image processing and analysis can be considered as a post-imaging or pre-analysis step which can play a particularly important role in diagnosis, planning, monitoring and evaluation of the treatment.

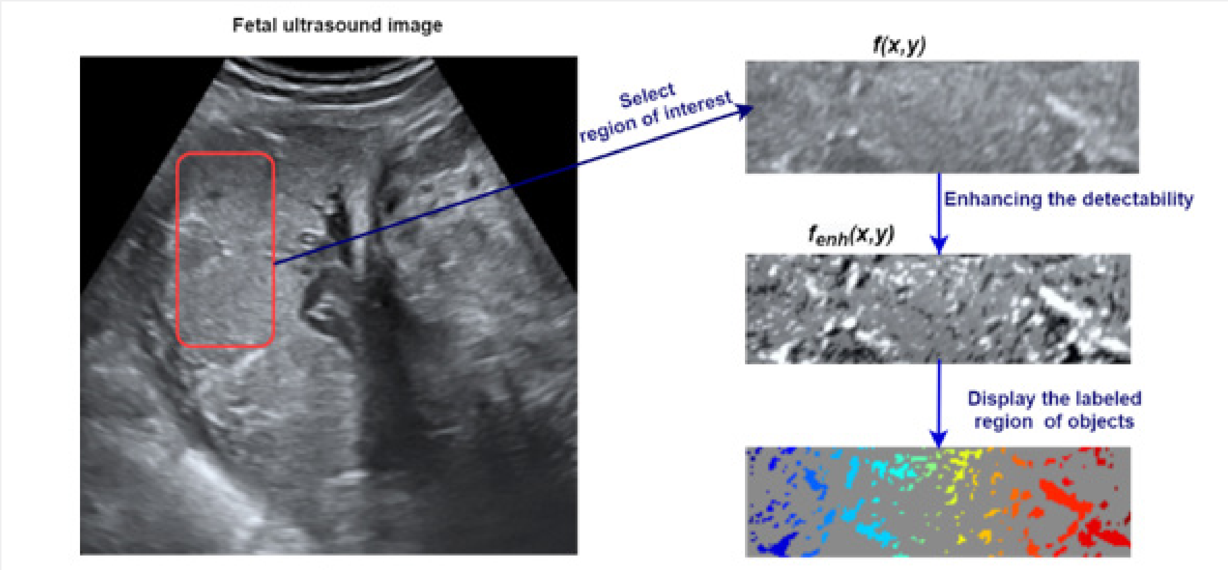


**Figure 2:** Major steps of microcalcification detectability.

Ultrasound is the most widely used imaging tool for obstetrics and gynaecology screening and diagnosis. Ultrasound scanners generate the images using the principle of pulse echo imaging. Pulsed acoustic waves, which can propagate through a tissue, with frequencies ranging between 2.5 and 10MHz are transmitted and received by a hand-held transducer. Although this technology is a mature one and has many advantages, the images obtained have in general low signal to noise ratio (SNR) and there are some main reasons for that. One reason is given by the fact that ultrasound scanners use signals that have short duration in time and therefore a broad-band frequency domain and this fact imply multiple noise sources that can affect the signal. Another one is given by the fact that sound waves are highly distorted when traveling through the tissues and consequently the quality of the image is affected by many types of artefacts. The artefacts play an important role in distorting the shape and texture of the structures and limit the detection of the obscure details in the images [12].

## Materials and Methods

In order to overcome the usual limitations of ultrasound scan, in terms of image quality, we propose an adapted image analysis method aimed at maximizing the detectability of placenta microcalcifications during pregnancy. The presented method is based on improving the details clarity in predefined regions of interest which implies a better contrast between different colours. The aim is then to improve the clarity of the details by increasing the contrast along the contours. This is a challenging problem when working with real clinical data because of the image noise and the large number of variables. An efficient way to solve this problem is to adapt methods for image enhancement in order to increase the perceptibility of microcalcifications in an image for a human observer.

### Image enhancement approach

In the medical field a medical image is considered a process in which the characteristics of the tissue are transposed into a grayscale or colour image. As a mathematical formal definition, the image is a function f(x,y) of two continuous variables x and y. This indicates the amount of brightness for each pair of spatial coordinates (x,y). The term spatial coordinates refers to all the whole of pixels p(x,y) of which an image is composed of. Each pixel is represented by an integer value from 0 to 255 in an 8-bit gray scale image. In the field of medicine usually are used 10, 12, 16 and respectively 24 bit/ pixel.

Therefore, image enhancement techniques are procedures that operate directly on the pixels. The aim of improving the quality of a medical image implies to enhance the contrast as well as minimizing the inherent perturbation factors [13]. Enhancement of the image contrast aims to improve the visual perception of objects contours because it is well known the fact that human perception is sensitive to the edges and fine details. In principle, this goal can be achieved by changing the pixel values

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that are on either side of a common border. The border can be seen as a transition from white to black (from one colour to another). Therefore, improving the contrast is supposed to produce a rapid transition from white to black which finally leads to a clearer image. Conversely, a gradual transition from white to black going through several grey levels leads to blurry images and unclear details.

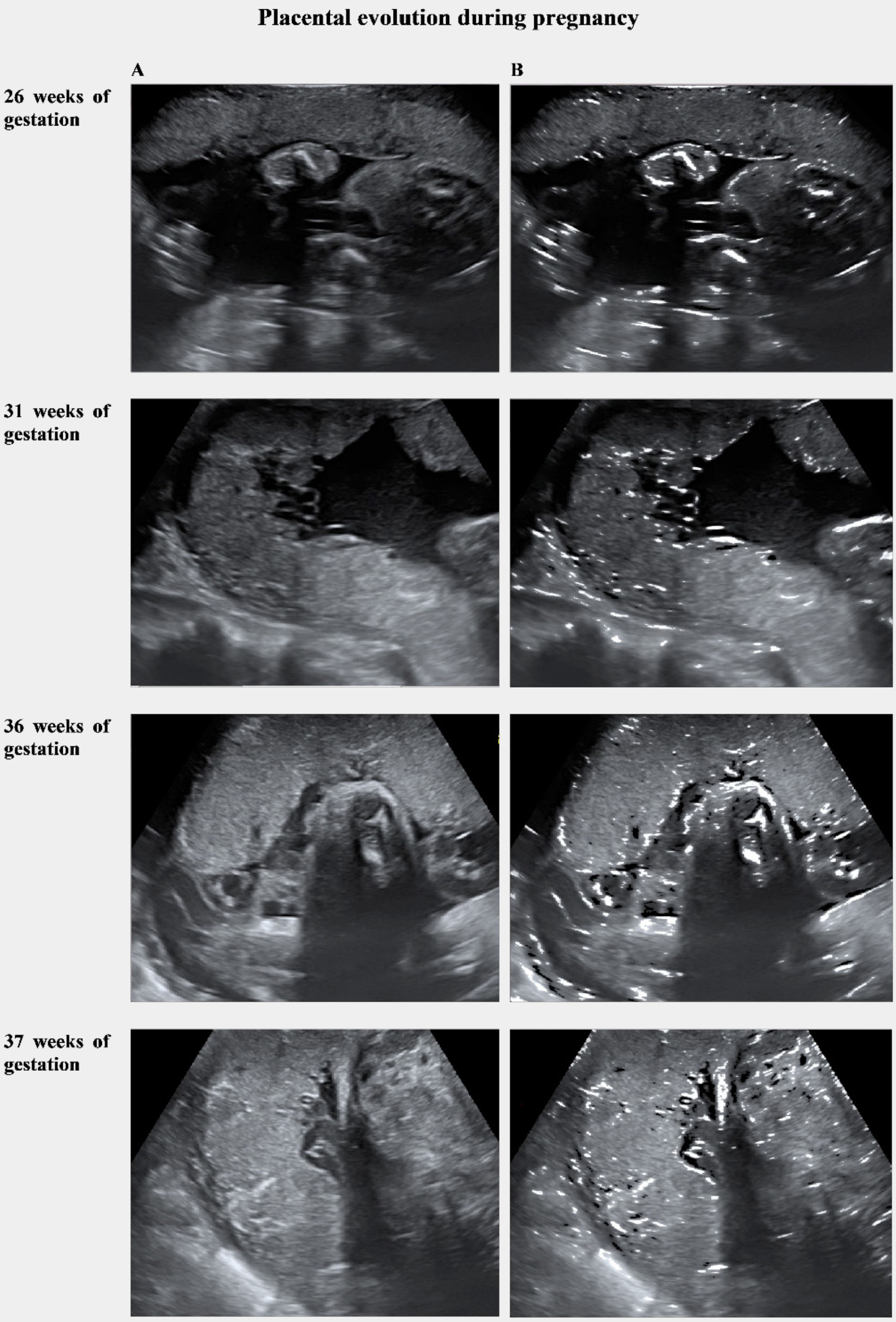


**Figure 3:** Placental microcalcification detectability at different gestational age.


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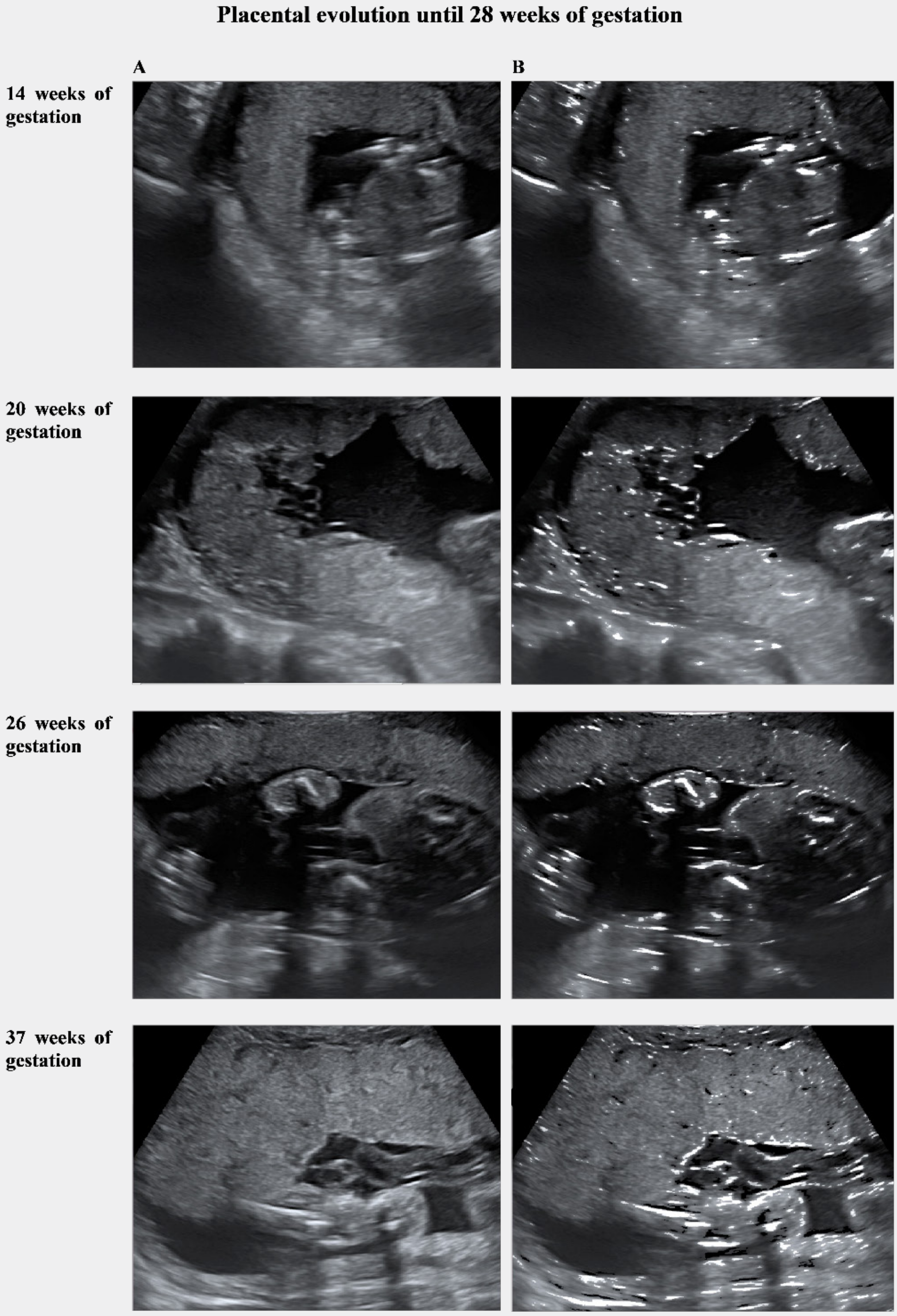


**Figure 4:** Placental microcalcification detectability between 14 and 37 weeks of gestation.

## Proposed method

Following classical approach, which is developed for image processing, we have implemented a filtering method specifically suited for detection of placental microcalcifications. This method implies firstly to filter the image with a high-pass filter in order to extract the high frequency components and secondly to



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add to the original image a scaled version of the filtered image, thereby producing an image whose contrast is enhanced between adjoining areas with little variation in brightness or darkness.

In order to build an enhancement image from a certain input image we have applied the following steps:

a) Select region of interest (ROI) identifying the location of potential calcifications. The ROI can be considered the original image f(x,y)

b) Apply a nonuniform low-pass filter that preserves low spatial frequency and reduces image noise without losing the principal features in order to obtain a smoothed image fsmooth (x,y) [13].

c) Apply an unsharp filter [14] in order to produce an edge image g(x,y): g(x,y) = f(x,y) – fsmooth (x,y), where f(x,y) is the input image

d) Add the original and the edge image: fenh (x,y) = f(x,y) + k × g(x,y), where k is a gain factor of the high frequency.

The output of the above method should lead to enhanced detectability of microcalcifications in the selected region of interest. Figure 2 presents the major steps described above.

### Practical implementation - clinical data

The results presented in this study were obtained using a set of 8 images corresponding to different weeks of pregnancy. All ultrasound examinations were performed using a Voluson E6 machine (General Electric Company) equipped with a 2-8MHz transabdominal GE RAB6-D transducer. For a better image quality, we randomly selected cases with anterior insertion of the placenta. Focus was set on the interest area and gain levelled so that amniotic fluid appeared totally black. The scope was to detect the regions showing micro-calcifications and to label it. ROI was selected using Image Tool and the simulations were made in Matlab.

## Results and Discussion

For the sake of visualization, we have chosen to present only zoomed visual results on a region containing microcalcifications. Figure 3 shows the influence of the filtering method in detectability of microcalcifications in the placenta for different weeks of gestation. We have observed the significantly enhanced visibility of less obvious microcalcifications (B) when compared to original ultrasound image (A).

Moreover, the image enhancement technique that we propose seems to be very reliable in the detection of preterm placental microcalcifications. One can notice that the proposed approach allows a better visibility of the small microcalcifications when these are difficult to identify in the original ultrasound images, especially before 32 weeks of gestation (figure 4 where A - original images containing microcalcification and B - corresponding images after improving details clarity).

## Conclusion

Early preterm placental calcification is associated with a higher incidence of poor pregnancy outcome, regarding the mother (postpartum haemorrhage, maternal transfer to the intensive care unit) as well as the foetus (preterm birth, low birth weight, low Apgar score and neonatal death). As showed in our study, an image enhancement technique allows a better visibility of the microcalcifications when compared with the original ultrasound image. In this respect, accurate detection of preterm placental calcifications could improve the overall outcome through a more intense maternal and foetal monitoring during pregnancy. Thus, the proposed method could be seen as an easy-to-use tool for early preterm placental calcification diagnosis and monitoring.

Although it is obvious that these image processing techniques could not be used on a regular basis in every pregnant woman, in selected cases detection of early placental calcifications could improve the foetal outcome through more active pregnancy surveillance. These techniques could be incorporated into the image processing software of the ultrasound machines as an add-on toolbox which could be used if the need arises.

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