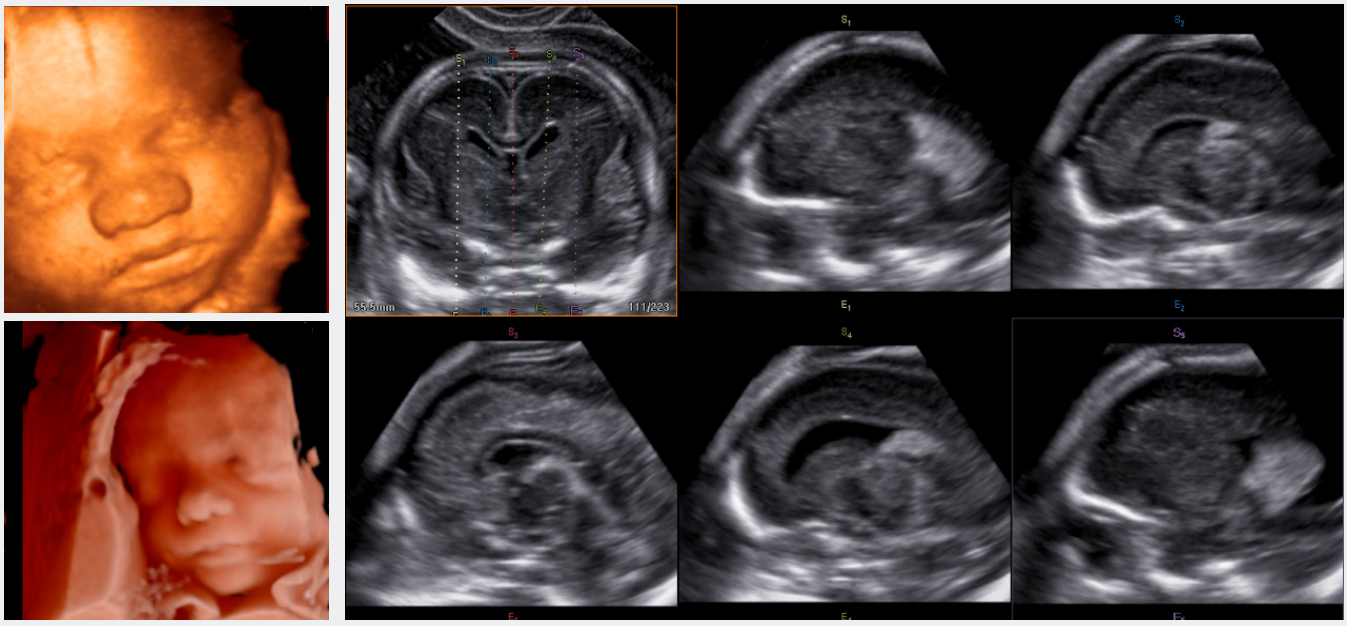
Article #WP201503-3DXI / Issue Date 30 Mar. 2015

New Techniques in Three-Dimensional Ultrasound

Daniel Cafici, M.D., Director

Teaching and Research, Argentian Society of Ultrasound in Medicine and Biology



" The use of 3D Extended allows very detailed handling of volumes, which makes it a very useful tool for understanding fetal anatomy during the whole gestation period. It also allows better understanding of anomalies obtained by conventional ultrasonography. "

Introduction

The incorporation of three-dimensional (3D) ultrasound (US) has made a great impact in obstetrics, displaying fetal anatomic structures, especially the face, in a more realistic way, which has been proven to have vital importance in prenatal bonding. However, besides providing excellent surface images, 3D technique shows the orthogonal plane and allows free ¨surfing¨ through the volume obtained. When working with state-of-the-art 3D equipment, operators often obtain fetal surface images but they fail to make the most of a variety of additional resources. The purpose of this article is to provide readers with a clear description and simple understanding of the different tools available in 3D equipment, which could be utilized in clinical practice or research.

Technical principles

3D ultrasound is based on obtaining a volume starting from a two-dimensional plane, which can later be processed in different ways. We will start by reviewing the several processes. In order to obtain a volume, an area of the fetal anatomy – the whole embryo in the first trimester, or the head of the fetus, for example - has to be ¨swept¨. This capture is obtained automatically by using a mechanical transducer.

SAMSUNG

In order to obtain the image, the size of the box may be adjusted in all three dimensions. The speed of capture can be adjusted as well, taken into account that captures at higher speed will yield a lower quality of image, and ignoring the existence of movement. The operator will choose the size of the box and the speed of capture depending on the part of the fetal anatomy will be explored.

Standard processing

Once the volume is obtained it can be processed in different ways in order to extract different data. The most widespread and usual way is called "surface rendering", where the surface of the fetus is observed. This modality is widely used in obstetrics in order to see the fetal face. A new technique named "feto realistic view" (FRV) is currently developed and provides a more realistic and well-defined image of the face (Fig. 1).

Another traditional way to study a volume is through multi-planar assessment. In this method, once a volume is obtained, three orthogonal levels are displayed simultaneously (Fig. 2).

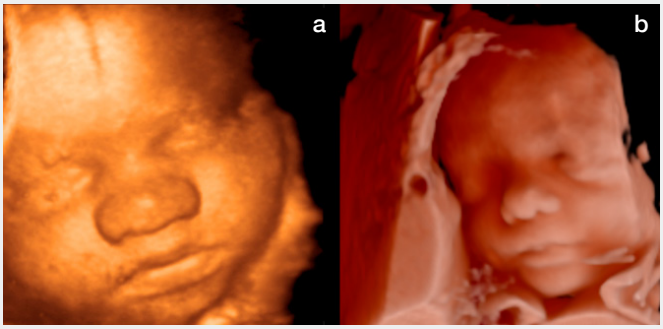


Figure 1. a) 3D surface rendering of the fetal face, b) surface rendering of the fetal face with fetal realistic view

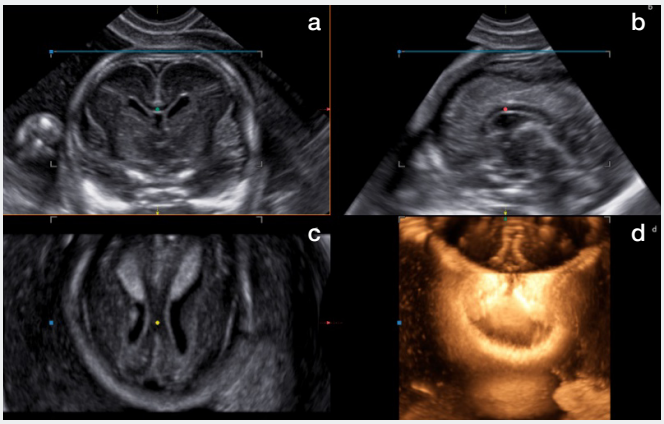


Figure 2. Multiplanar rendering: the three planes of this fetal brain volume are simultaneously displayed. The volume was obtained on the coronal plane (a), and the sagittal (b) and axial (c) planes are also observed as well as the surface reconstruction (d).

The operator can then scroll one of the planes in any direction and the corresponding changes in the other planes will be seen. On each of the planes there is a "point", which serves as orientation, since it points to the same structure in each of the planes. A point is located in the structure we want to visualize in the three different planes. In this case, it is located at the corpus callosum.

New ways to process volume

Samsung Ultrasound equipment has the possibility to handle volume in detail through the 3D extended view system (3DXI). This system includes several abilities such as multislice view (MSV) oblique view (OV), oblique view extended (OVIX) among others.

We will develop in this section the mechanics of using the main tools for studying three-dimensional volumes.

Multi-plane rendering (MPR)

The MPR allows the three planes of a volume (sagittal, axial and coronal) to be observed simultaneously, adjusting the section height according to needs. For instance, if the volume is obtained from the sagittal plane, the axial and coronal planes will also be observed. The operator can then scroll one of the planes in any direction and the corresponding changes in the other planes will be seen. On each of the planes there is a "point", which serves as an orientation, since it points to the same structure in each of the planes.

The images corresponding to those planes will be displayed on the screen and a point will be located in the structure we want to visualize in the three different planes. This technique allows the operator to identify a structure, which can be more easily recognized in one of the planes, in the other ones as well. The operator chooses the ¨surfing¨ plane freely, and in general, through a combination of movement in two planes, the desired structure can be located. (Fig. 2)

Multislice view (MSV)

With this application, multiple parallel sections of a volume are made automatically in the desired plane. The operator can modify the reference plane and the thickness of the section (0.5 to 5 mm) and the number of images shown on a screen (1x1, 2x1, 3x2, 4x3 or 6x4). Besides, as in all of these applications, the images can be rotated in different directions and enlarged (Fig. 3, 4).

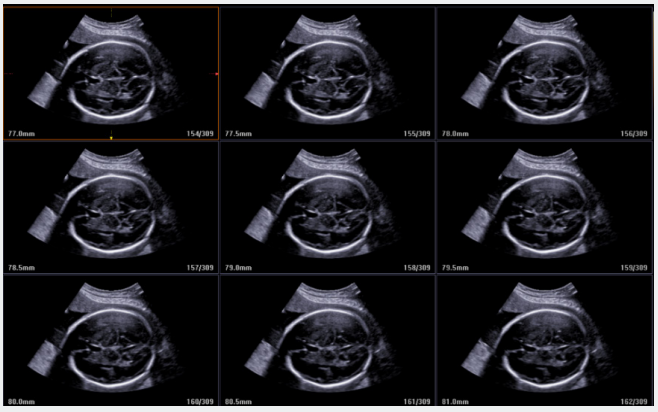


Figure 3. "Multislice view": multiple parallel sections of this volume of the fetal head are automatically displayed

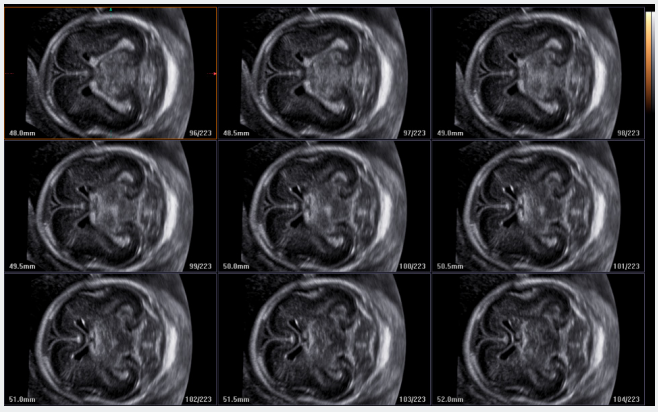


Figure 4. "Multislice view": Images at the bottom shows the cerebellum

Oblique view (OV)

It examines a non-conventional plane of a volume. The desired observation plane may be straight or curved, since the operator traces the line freely. This allows observing, from a certain section, the plane that is perpendicular to that section (Fig. 5, 6). Additionally, it is possible to surf the volume in different sections and section planes. The possibility to obtain a curved line is useful especially for areas of the fetal body whose morphology is not straight, as are the spine and the palate, for example.

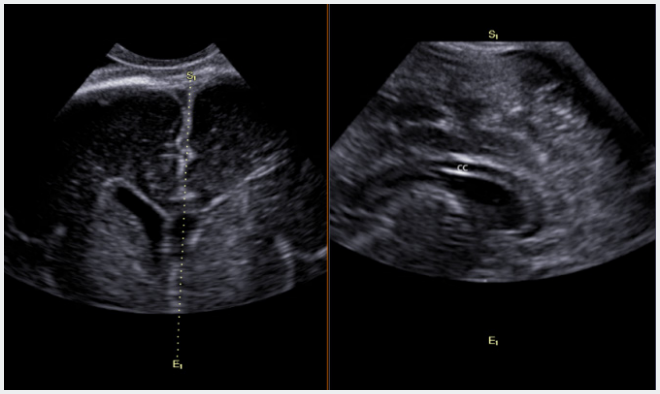


Figure 5. "Oblique view": On the left the image of a coronal section of the volume. A line was traced and on the right the image of the corpus callosum (cc) is displayed. S1 and E1 represent starting and ending point of the line traced by the operator

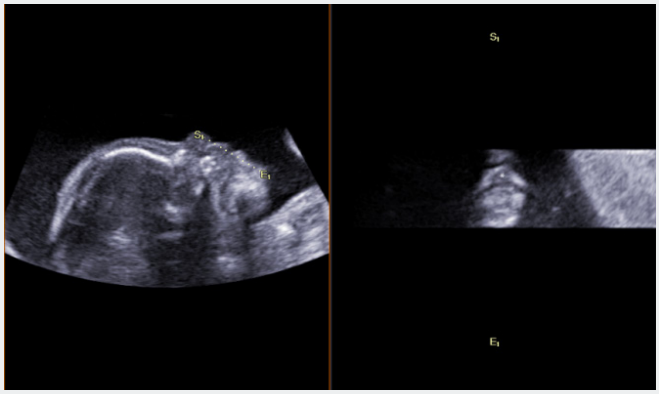


Figure 6. "Oblique view": On the left the image of a sagittal section of the fetal face. A line was traced and on the right the image of lips (l) is displayed

Oblique view extended (OVIX)

It provides a variation of the oblique views in which the section is displayed with a greater thickness, which can be changed by the operator (Fig. 7).

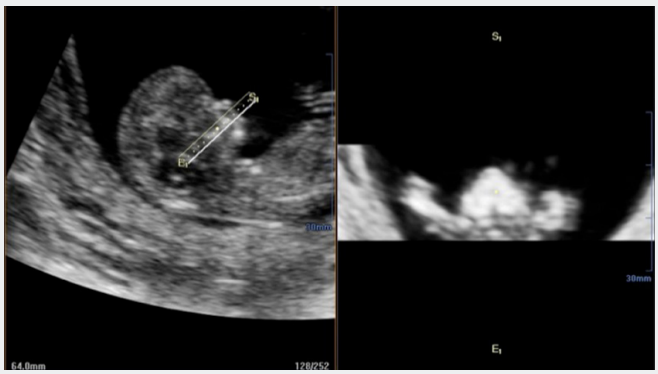


Figure 7. "Oblique view extended" (OVIX)

Multiple oblique view and multiple oblique view extended (OVIX)

It allows tracing on the plane of a volume, multiple lines which display the corresponding sections simultaneously. The operator can select the thickness of the section as well as the number of sections displayed on each screen. Additionally, rotating the image freely can vary the section plane (Fig. 8, 9).

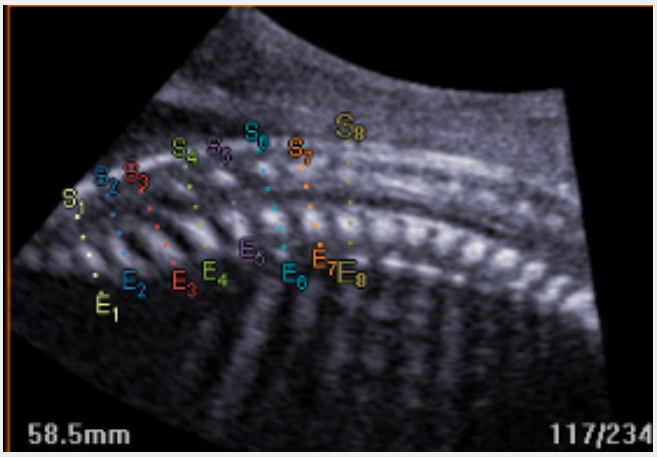


Figure 8. "Multiple oblique view" Different axial section of the spine are displayed in axial views from a volume obtained in the sagittal view

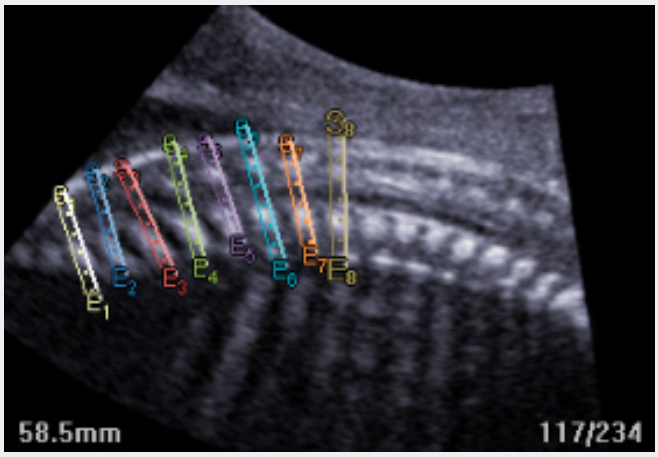


Figure 9. "Multiple oblique extended" (Multi OVIX)

Applications in obstetrics of 3DXI

- Nuchal translucency (NT) and intracranial translucency (IT)

3D ultrasound can be useful in identifying the NT and the IT. Obtaining the correct angle to identify it by three-dimensional volumetrics may be performed through different techniques such as MPR, MSV or the latest incorporation: automatic measurement of the NT.

For all three variations, the first necessary condition is obtaining a volume of the fetus focused on the head and upper thorax. The volume must be of adequate quality, not very far – preferably under 30 degrees – from the most precise median sagittal plane, and with an adequate view of the nuchal region.

Once the volume is obtained by MPR the three orthogonal planes will be observed and the image will be able to be rotated in one of them, preferably the axial or sagittal plane, in order to locate the adequate median sagittal plane. Afterwards, the image can be enlarged and the measurement is carried out.

If the MSV is used, the section that best represents the median sagittal plane will be selected in the succession of sagittal sections, magnified, and the NT will be measured.

Finally, by using the automatic reading of the obtained NT, the operator proceeds to locate a point in the image of the fetus diencephalon and then the software carries out a rotation of the volume in order to identify the median sagittal plane automatically (Fig. 10).

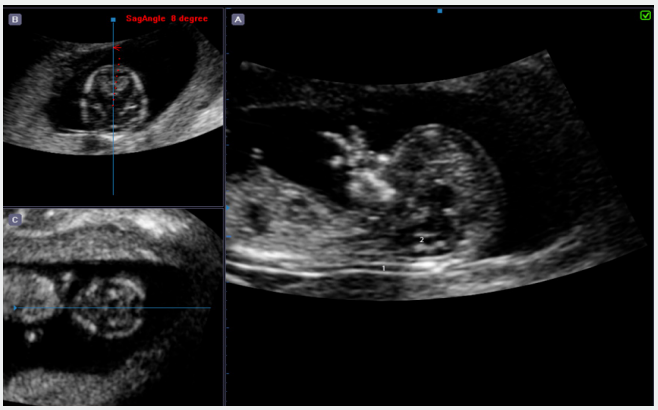


Figure 10. "Automatic nuchal translucency" The software adjusted automatically the median sagittal plane making an 8° degree correction (upper left) The NT(1) and IT (2) are visualized at the right

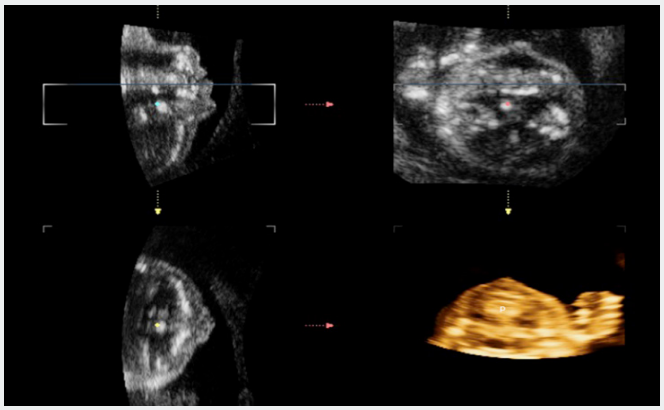


Figure 11. Reconstruction of the fetal palate with MPR

Palate evaluation

Lip or alveolar rim fissures can be easily diagnosed with conventional two-dimensional ultrasonography. However, the secondary palate is difficult to evaluate due to its concave shape and the fact that it is surrounded by bone structures that cast shadows and generate image artifacts. For this reason, US3D is a very useful alternative, especially if a curved line can be traced for capturing the volume. For palate evaluation, MPR and OV are the best alternatives (Fig. 11, 12).

In the first trimester Sepúlveda and cols described retronasal triangle (RNT) (Fig. 13) which captures the alveolar rim and the maxillary frontal processes in a coronal plane simultaneously, allowing the primary palate to be evaluated; and they also reported the possibility of examining the secondary palate by observing the previously obtained volumes. In this case, oblique section is necessary. We have recently described the utility of employing the algorithm of automatic reading of the NT (Volume NT™ /5D NT™) combined with OV and OVIX in order to evaluate the fetal palate during the first trimester. It obtains a exact median sagittal section from a volume first, using "Volume NT™"or "5D NT™" in order to obtain orthogonal sections later by using OV or OVIX. Once the image of the palate is obtained, it can be scanned by being move to the reference line.

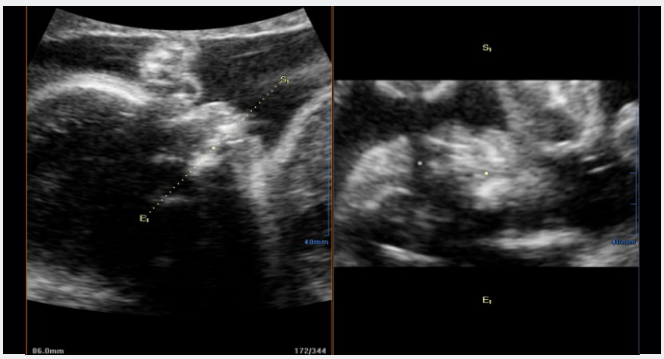


Figure 12. Depiction of a cleft palate (*) with OV

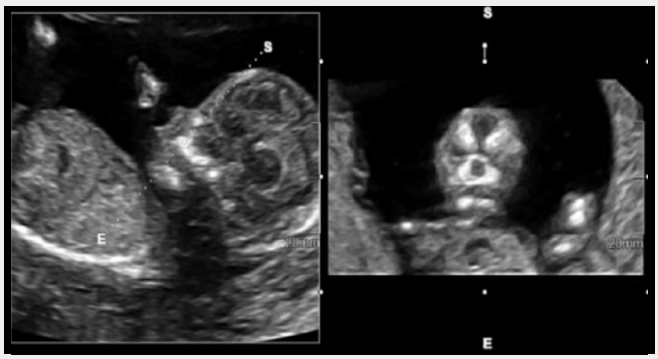


Figure 13. Retronasal triangle identified with OV

It is also possible, through automatic reading, to identify the nasal bone , the RNT and the intracranial translucency, having established reference values for the intracranial translucency by examining three-dimensional volumes.

- Central nervous system

In the second trimester, 3D ultrasonography can be useful in identifying the sagittal plane in the fetal brain in order to evaluate the corpus callosum, cerebellar vermis and other structures of the median line. It also allows axial and coronal sections of the spine. Additionally, it can collaborate in evaluating cortical gyri and sulci of the fetal brain. The most used applications with this purpose are MPR, OV and its variations and MSV (Fig. 14). Surface assessment can show very eloquent images.

Besides its utility in evaluating the structures mentioned above, volume searching with MPR, OV or MSV allows to identify several anatomic aspects during pregnancy through detailed study of volumes.

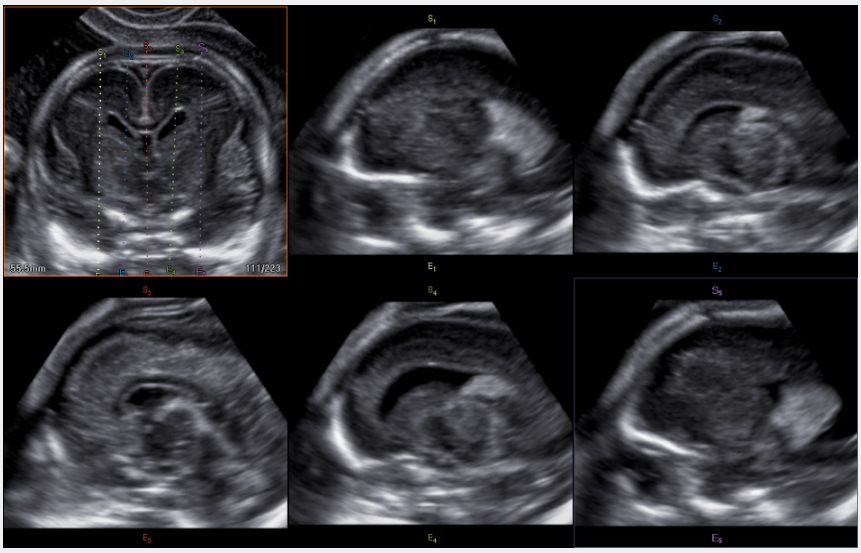


Figure 14. Multiple sagittal planes of the fetal brain obtained with Multi OV from a coronal plane

Conclusion

The use of 3D Extended allows very detailed handling of volumes, which makes it a very useful tool for understanding fetal anatomy during the whole gestation period. It also allows better understanding of anomalies obtained by conventional ultrasonography.

This simple and user-friendly tool is a very valuable element in daily practice.

Supported Systems

(1) WS80A with Elite

SAMSUNG