ADVANTAGES OF USING A MULTIFUNCTION ULTRASOUND SYSTEM
With 10, 20 MHz Sector Probes & 50 MHz Linear Probe : AVISO by Quantel Medical

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INTRODUCTION

Using Ultrasound Systems in common practice allows you to solve many diagnosis problems in posterior segment pathologies, but also in glaucoma cases and, now, thanks to higher frequency probes, in refractive surgery.
We have tested the new Quantel Medical AVISO system with all the available probes.
The 10 MHz probe, more routinely used, gives a posterior pole image in case of transparency loss of the media. Increasing the probe frequency allows better and better resolution to analyse the retina and particularly the posterior pole.
The advantage of the long focal 20 MHz probe is to give access to the posterior pole and also to the retinal periphery with a better resolution than with the 10 MHz. The possibility to explore the posterior pole with high frequency probes has been described for the first time in 1999 by M. Puech MD (patented invention reference: M. PUECH PCT FR98 / 02788).
The AVISO System also operates with short focal probes specifically designed to explore the anterior segment.
The linear Probe, at 50 MHz, makes it possible to display various sections of the anterior segment with a very high resolution and large scanning amplitude (16 mm). The advantage of this 50 MHz linear probe is to give measurement and analysis possibilities in refractive surgery, glaucoma and irido-ciliary tumor cases.

MATERIAL and METHOD

We have used the AVISO Ultrasound System (Quantel Medical, Clermont-Ferrand, France).
This system is equipped with a 10 MHz Probe focused at 25 mm for vitreous and posterior segment exploration.
A 20 MHz Probe, with Long Focal (24 mm) is used for sharp analysis of pathologies in the posterior pole.
A 20 MHz Probe, with Short Focal (8 to 10 mm) is used for analysis of the anterior segment.
The 50 MHz Probe with Short Focal (5 to 7 mm) and Linear Scanning is connected to the same unit.
The advantage of this versatile system is to enable the user to connect different probes to the same central unit, according to the explored pathology.
The Ultrasound system is based on a PC computer, under WindowsXP operating system, with powerful storage and image processing capacity. The fully digital imaging offers large zooming capacity and use of several measurement tools after image acquisition.
A Cineloop function provides a 10 seconds image sequence. This allows a backward display of all images in order to choose the most representative for the current examination. Replaying the entire sequence can show the kinetics of some pathologies such as movements of the vitreous body or the response of the irido-corneal angle to a light stimulus.
Our study has been carried out on 142 patients (237 eyes):

- 72 patients, (116 eyes) were sent for exploration of posterior pole pathologies
- 35 patients, (70 eyes) for anterior segment pathologies including closed irido-corneal angles,

- 12 patients, (24 eyes) for anterior segment measurements before phakic implantations,
- 15 patients, (15 eyes) for tumoral pathologies of iris or ciliary processes,
- 8 patients, (12 eyes) for posterior chamber IOL analysis.

For the posterior segment exploration the 10 MHz probe was used to get a general view of the vitreo-retinal condition.
Then a complementary exploration was done with the 20 MHz probe in order to observe with high resolution the area of interest.
This procedure is very useful to identify small solid lesions of the inner wall (naevus or tumors), peripheral tears, splitting of tissue layers (retinoschisis, retinal detachment, choroidal detachment) or age related macular degeneration.

The 50 MHz Linear probe was used for the anterior segment exploration. With a large scanning window, it allows display of a complete section of the anterior chamber through the corneal vertex, the lens apex and the posterior lens and also display of the irido-corneal angles, the ciliary sulcus and the ora serrata.
When the examination is needed for a more specific pathology in the irido-corneal angle (closed angle or irido-ciliary tumor) it is done in a zooming position so as to get a magnified image comparable to that obtained with the UBM (Paradigm, Salt Lake City, USA).
Another positive point of the 50 MHz probe is that it is a closed probe with a transducer protection membrane which doesn't absorb any ultrasound energy. The membrane is changed for every new patient to ensure that the probe remains sterile

RESULTS

1) Posterior segment analysis

Using 10 MHz and 20 MHz long focal probes permits a thorough examination of the posterior segment whatever the transparency loss of the media **(Fig. 1).**
Dense cataracts and intra-vitreous haemorrhages do not impair access to the retina.
The 20 MHz probe increases analysis resolution and comes close to OCT resolution because it is not impaired by transparency loss of the media and allows peripheral retina imaging.
This feature is extremely useful when exploring peripheral lesions or tumors in the case of important transparency loss.
The high resolution allows visualisation of the thinnest outside layer of some peripheral melanomas.
A 20 MHz Long Focal probe used in conjunction with a 50 MHz Linear probe focused on the peripheral sclera make it possible to detect the anterior limit of a tumorous lesion and to diagnose either a ciliary body invasion or the limit of the lesion before the ciliary body.

Anomalies of the peripheral vitreous-retinal junction can be analyzed with much finer detail, including visualization, in certain cases, of retinal tears and retinal detachment.
Differentiating the various detached layers, as in retino-schisis associated with retinal detachment, is made easier with the high resolution offered by the 20 MHz long focal probe.
Analysis of macular lesions can be very efficiently complemented with ultrasound imaging which, contrary to OCT, can go through pigmented lesions such as macular hemorrhages in age-related macular degeneration or choroidal melanomas.
Exploration by ultrasound allows analysis of choroidal structure as well as early diagnosis of evidence of scleral invasion found in certain types of melanoma.

2) Analysis of the anterior segment

Exploring the anterior segment is meaningful mostly in the three following cases:
glaucoma, refractive surgery and irido-ciliary tumors.

a) Glaucoma

In glaucoma cases an anatomical check up of the eyes can be done before a therapy decision is made. One of the most useful applications of high frequency imaging with the 50MHz linear probe is found in the exploration of a narrow irido-corneal angle **(Fig. 2).**
This exploration can be carried out under ambient lighting in the examination room which permits analysis of the opening of the irido-corneal angle in a photopic environment**.** When the room is plunged in darkness the dynamic response of the irido-corneal angle can be directly observed, sometimes showing a significant closing of the angle with a simultaneous bulging of the iris towards the cornea, which implies high risk of glaucoma through closing of the angle.
The advantages of high resolution analysis have been known since UBM was introduced but to be able to get a complete image of the entire anterior segment now permits a finer analysis of iris responses, positioning of the crystalline lens as well as ciliary-processes response.
It is then possible to establish the difference between a narrow angle which remains open during physiological mydriasis (low risk of angle closure glaucoma) and a narrow angle which closes under physiological dilation of the pupil (high risk of angle closure glaucoma). Indications for treatment by iridotomy with a Nd-YAG laser are therefore more precise and based on objective elements.
Analysis of the positioning of the ciliary processes sometimes reveals a plateau iris syndrome in which the tilting of the ciliary processes in front of the scleral spur brings them in contact with the base of the iris. In this case treatment by iridotomy often proves inadequate and a more specific treatment of the plateau iris condition has to be sought.

Check ups following filtering surgeries (trabeculectomy and deep sclerotomy) can be carried out with the 50MHz probe. The sclerotomy and the quality of the filtering bubble can be visualized and it is possible to analyze the mechanism of a poor response to surgical treatment **(Fig. 3).**

b) Refractive surgery

In the case of refractive surgery with phakic implant, the 50 MHz short focal probe provides a good visualization of the whole anterior segment, which cannot be obtained through the UBM's window. This feature, together with the visualization of the cornea over the whole scan allows pre-operation measurements in order to determine the size of an angle supported phakic implant. Measurement of the distance from white to white is not perfectly correlated to the actual angle to angle distance or the sulcus to sulcus distance. The depth of the anterior chamber needs to be measured in order to respect the safety distances of the implant and avoid any risk of contact between the anterior chamber implant and the cornea.
Analysing the aspect of the angle before phakic IOL implantation, also allows detecting the possibility of a high risk of pupil ovalization **(Fig. 4).**

In a post surgery examination, the positioning of a phakic implant in the anterior segment is very accurately evaluated thanks to the 50MHz linear probe: measurement of distances between the implant and the cornea, between the implant and the crystalline lens **(Fig. 5).** The advantage of ultrasound exploration is also to provide a clear visualization of the positioning of the implant footplates in relation to the anatomical structures of the angle. Zoom images of the irido-corneal angle permit a very good analysis of the positioning of these implants.
OCT imaging of the irido-corneal angle with implant is often limited.

Analysis of posterior chamber implants is achieved only by ultrasound systems. Units based on OCT imaging of the anterior segment are limited by lack of penetration of the signal behind the iris. The 50 MHz linear probe offers a good visualization of all structures back of the iris together with a complete sulcus to sulcus section. This makes it possible both to determine implant size in the pre-op phase and

to check the positioning of the implant in the post-op phase with analysis of the interaction between implant and crystalline lens, iris and ciliary processes.

c) Irido-ciliary tumors

In irido-ciliary tumor cases, the 50 MHz probe allows high resolution analysis of tumors presenting a high level of ultrasound absorption **(Fig. 6).**
With the large width linear scan of the 50 MHz probe it is possible to obtain complete images of even the biggest lesions and measurements of all the lesions explored. This proves extremely useful especially as the UBM device (Paradigm, Salt Lake City, USA) is of limited use for all tumors exceeding the size of its exploration window (5mm x 5mm).
The connections of tumors with the various elements of the anterior segment are extremely well analyzed with the 50 MHz probe, either in zoom mode or by displaying the complete section of the anterior segment, so as to evaluate, for example, the response of the crystalline lens to a ciliary melanoma (cataract, displacement).

DISCUSSION

The new ophthalmic ultrasound systems are multifunctional devices with a growing number of different probes allowing exploration to focus on this or that particular part of the eye.
In some cases, OCT devices still give better image resolution, especially of the macula; however they are affected by loss of transparency of the media and have limited access to peripheral lesions. Ultrasound exploration suffers from no such limitations and offers adequate resolution levels in the majority of cases.
The penetration capacity of ultrasound devices allows better analysis of irido-ciliary tumors than do OCT devices. The AVISO's 50 MHz linear probe with its large scanning width proves superior to other short focal ultrasound probes for measuring large tumors. It gives better image resolution than short focal 20Mhz probes and its exploration window encompasses the whole anterior segment, contrary to UBM devices which are known for their high resolution imaging but do not have a wide enough window for large lesions.
This feature of the 50 MHz probe is useful again when dealing with a phakic implant in the posterior chamber. The connections between the optic and the haptic of Phakic IOL on the one hand and the iris, the zonules and the ciliary-processes on the other hand, can be visualized.
Imaging systems designed for exploration of the anterior segment are more and more frequently used to establish with accuracy which patients should be treated by refractive surgery with phakic implants.

CONCLUSION

Ultrasound imaging is making progress thanks to the use of higher frequency probes that improve resolution levels of the images displayed. AVISO from Quantel Medical introduces an innovative element in eye exploration. A 50 MHz short focal linear probe can be connected to it for improved analysis of the anterior segment. This probe gives very high-resolution images of the anterior segment and its wide exploration window allows display of the whole anterior segment. This very high resolution system equipped with a zoom mode to focus on a selected area opens the way for a precise exploration of the irido-corneal angle, the anterior segment and the posterior chamber. Applications for this kind of imaging are found in three types of cases: glaucomas, requiring analysis of the irido-corneal angle; tumor-related pathologies calling for visualization of irido-ciliary lesions; refractive surgery with a check up before and after phakic implantation.

Different probes with different characteristics according to the point of interest of the examination can be connected to the AVISO unit, making it a very versatile device in every day practice. The AVISO's 10 MHz probe is complemented by the 20 MHz long focal probe which improves analysis resolution for the

posterior segment, while the 50 MHz linear probe allows high resolution analysis of the anterior segment.

Comparing the AVISO's ultrasound images to images obtained with UBM or OCT units reveals that a single unit equipped with various probes can provide high resolution imaging of numerous diagnostic problems.

FIGURES:

Figure 1: Parietal thickening on diabetic retinopathy.

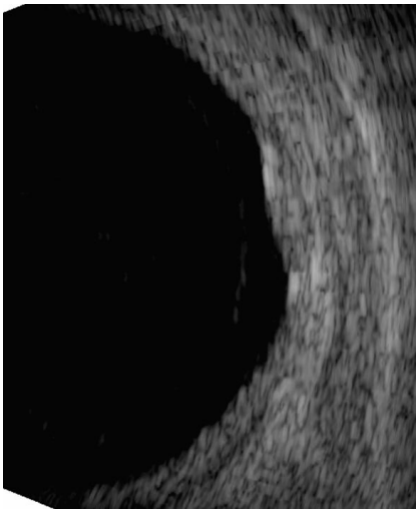

Figure 2: Aspect of an Irido-corneal angle zooming and focusing on the angle.

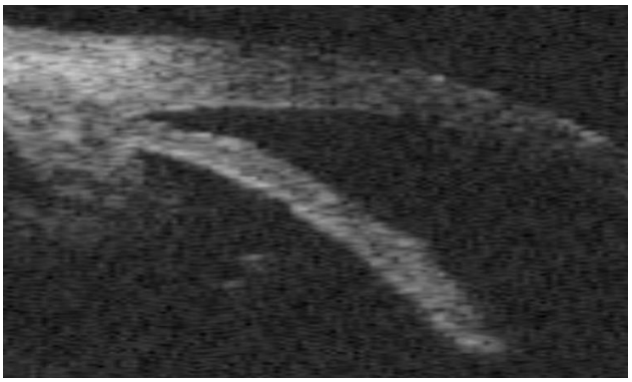

Figure 3: Section through a trabeculectomy and display of the sclerectomy in the irido-corneal angle and filtration analysis.

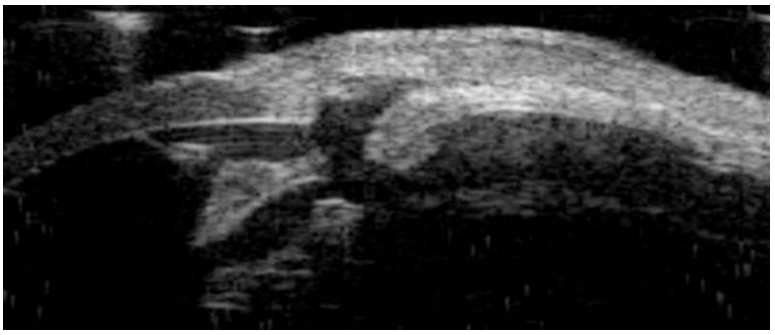

Figure 4: Section of the whole anterior chamber used for all biometric distances before a phakic implantation: anterior chamber depth; “angle to angle” and “sulcul to sulcus” distances.

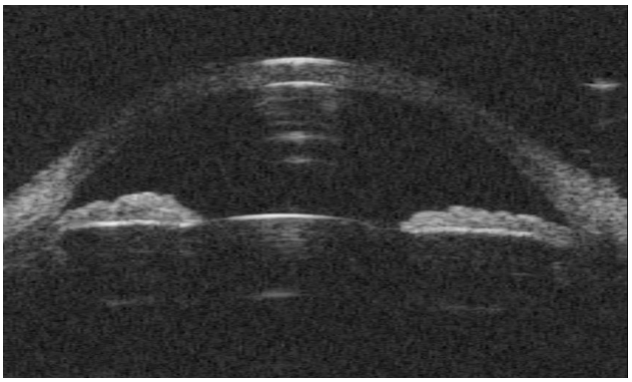

Figure 5: Anterior chamber section with an Artisan Implant: the measurement of security distances can be done for post-op checking.

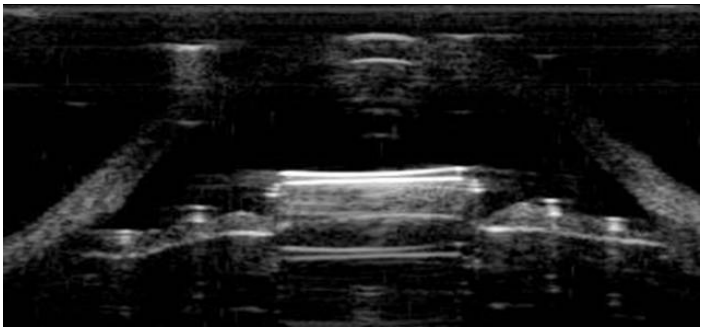

Figure 6: Section of Iris melanoma treated by **proton therapy:** the ultrasound penetration allows a fine analysis of the lesion structure over all its thickness.