Letter to the Editors

How Tablet Technology Is Going to Change Cooperative Diagnosis in the Cytology e-Laboratory

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Dear Editors:

Digital cytology is a field of digital pathology[1,2] that, through the integration of suitably designed information and communications technologies and medical knowledge, allows the investigation of cellular morphological alterations directly in a digital image called a virtual slide or e-slide[2–4] in a cytology e-laboratory. The e-slides are the product of a digitalization workflow produced by means of a heterogeneous process through the use of dedicated scanners starting from a standard microscope slide. To date, cooperative diagnosis is obtained using a multiple-head microscope. This system is based on a microscope connected to several binocular visors by means of optical bridges.

A system of this kind is hierarchical and despotic:

- It is hierarchical because is evident that there is a hierarchy of two levels between the nodes: the higher level one is the node where the microscope is, and the lower ones are the nodes where there is a passive binocular visor.
- It is despotic because one and only one drives the navigation (i.e., the coordinator sitting at the node with the microscope).

The evolution of cooperative diagnosis is strategic for the process of diagnosis and for teaching purposes in the cytology e-laboratory. The investigation of the relevant evolution linked to the introduction of tablet technologies is thus a basic issue for the healthcare system. The present study thus aims to investigate modifications of cooperative diagnosis in the cytology e-laboratory introduced by the new tablet technologies with particular reference to workflow and required skills.

The available tablet technologies of potential use in sharing image information in digital cytology and thus of interest in this study are as follows[5]:

- Wearable tablets (i.e., that can be positioned in a pocket like a smartphone)
- Portable tablets (i.e., that can be contained in a briefcase like an Apple [Cupertino, CA] iPad®)
- Nonportable tablets (i.e., the large virtual touch tables like the Epson [Long Beach, CA] Xdesk®)

In general, all the above tablets have the advantage of allowing finger touch screen–based image management. Using the fingers, moving, panning, zooming, image speeding operations, and user-friendly interaction with the screen are all possible.

The first two systems, which are widely used for many different purposes, allow anyone in the world to be reached, thus affording

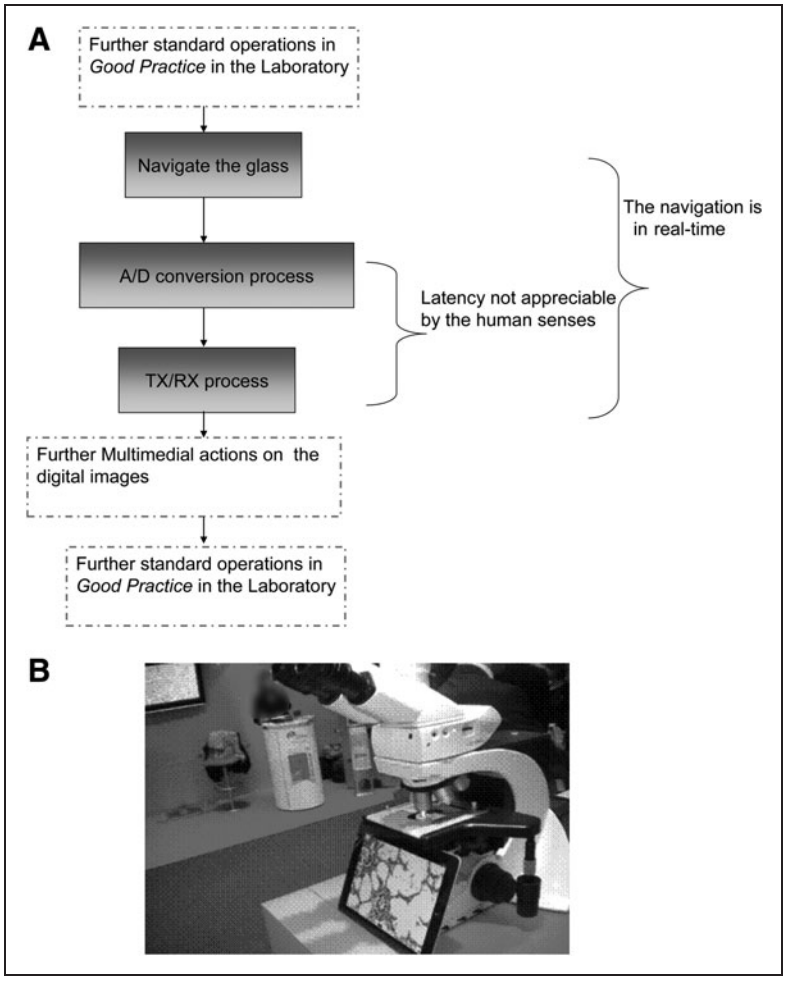

Fig. 1. (A) Revised workflow in the first scenario. **(B)** Navigation using the DMshare system. A/D, analog to digital; TR/RX, transmitter and receiver.

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digital cytology consulting through both in-hospital and outside-hospital local area networks.

The latest technology, like, for example, the Epson XDesk, represents a powerful information and communications technology solution for on-site cooperative analysis and discussion of digital cytology cases.

Two completely different scenarios of utilization of tablet technologies for cooperative diagnosis in the e-laboratory are possible:

- The first scenario is represented by a microscope connected via a digital camera to a transmitter/receiver using a radio bridge capable of broadcasting information by wireless to client tablets connected to the system. It works directly on standard slides and in real-time just like the multiple-head microscope. All the interactions take place in real time on the actual slide (latency due to the digital transfer is not perceptible to the human eye); the traditional multimedia operations can be used on the images. *Figure 1A* shows the work flowchart in order to illustrate the skills required for using the system. One example of a solution in this direction is represented by the DMshare® system by Leica Microsystems (Wetzlar, Germany), which uses a proprietary system to allow connection to up to 100 iPads (*Fig. 1B*).
- The second scenario is represented by the use of a nonportable tablet to achieve completely interactive navigation. It works on e-slides which can be obtained by means of different proprietary solutions. Unlike the multiple-head microscope system and the previously described one, it is nonhierarchical and democratic: each subject around the table can interact with the e-slide using the touch screen functions, and all the interactions are in delayed real time as they act in the virtual, and thus not in the actual, slide (the delay is the time taken to scan the slide plus the positioning of the e-slide on the server). All multimedia operations can be used on the images. *Figure 2A* shows the work flowchart to further illustrate the skills required for using the technology. *Figure 2B–D* focuses on the navigation scenario.

This study has indicated two different directions of evolution for cooperative diagnosis in the cytology e-laboratory based on tablet technologies. At this stage the two aspects to be considered in the introduction of the two technologies are cost and acceptance when compared with the traditional multiple-head microscope.

In the case of the first scenario, the tablet could be considered as a tool available to operators for their daily activity in the e-laboratory and thus not for exclusive use in cooperative diagnosis. Furthermore, comparison with the multiple-head microscope must take into account:

1. the cost of the two systems alone and
2. the cost of the virtual connection compared to the cost of the optical bridge.

The approach to cooperative diagnosis becomes completely different in the second scenario. First, costs are fixed and are a function of the digitalization process and of the nonportable wearable tablet. Second, it should be considered that the number of subjects around the virtual table is limited.

The use of tools for the health technology assessment is basic for the assessment of acceptance and the performances of the new technologies in the cytology e-laboratory to investigate both the performance and the users' acceptance. We are currently developing a tool for health technology assessment that is specific to tablet technologies used in digital cytology, starting from a previous telepathology-focused experiment.[6]

In conclusion, the present study represents only a preliminary investigation regarding the introduction of tablet technologies in the

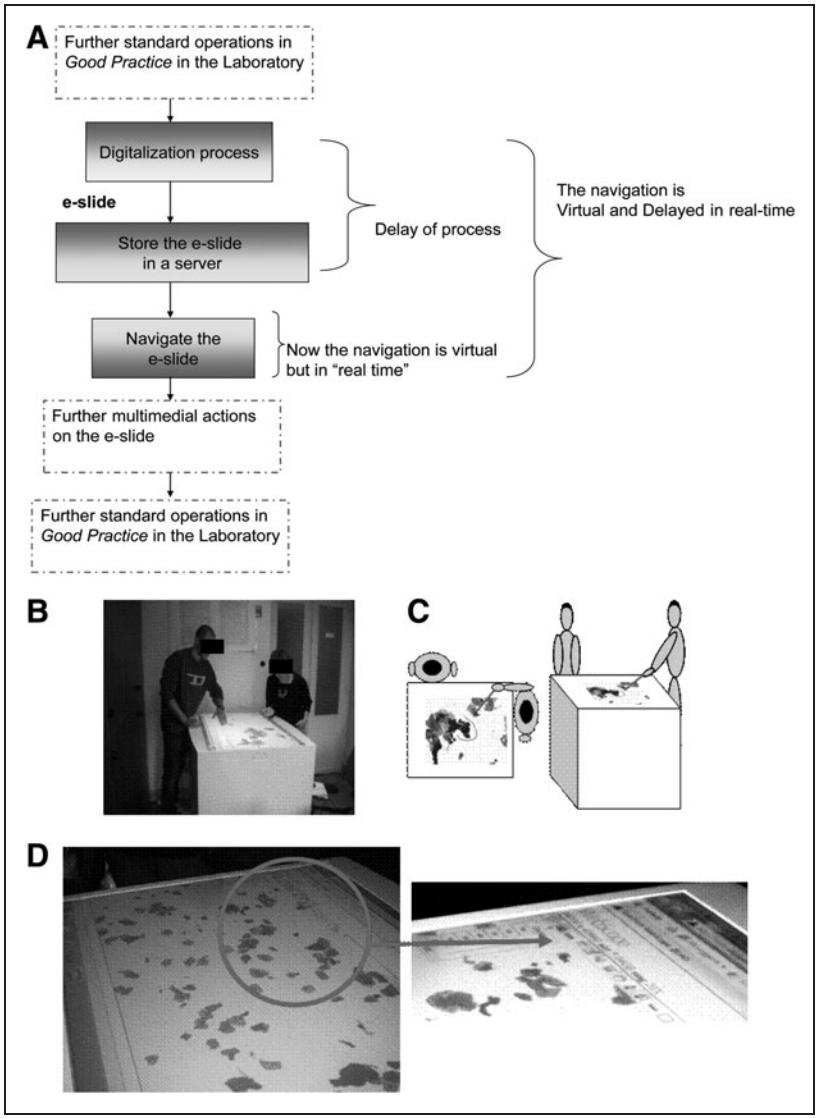

Fig. 2. (A) Revised workflow in the second scenario. **(B** and **C)** Experts during diagnosis. **(D)** Details on navigation by means of the Web-Viewer by Aperio® (Leica Biosystems, Vista, CA).

cytology e-laboratory. As the fields of interest are broad, we have focused in this study on a single aspect. Assessment of the introduction of tablet technologies in teleconsulting and e-learning applications will be the focus of future study.[3,4] We trust that stakeholders will focus on this field in order to translate these research experiences into routine and practice.

Disclosure Statement

No competing financial interests exist.

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