Correspondence

Augmented reality in Mohs micrographic surgery

Dear Editor,

Augmented reality (AR) is a set of technologies that superimpose digital information on the physical world, bringing components of the digital world into a person's perception of the real world, and it does so not as a simple display of data but through the integration of immersive sensations that are perceived as natural parts of an environment.[1] The appearance of AR in healthcare is a natural consequence of the technological development and data boom. Health records have changed from paper to electronic format worldwide, and medical care might depend on whether the doctor can have access to the latest and most relevant data in the easiest possible way.

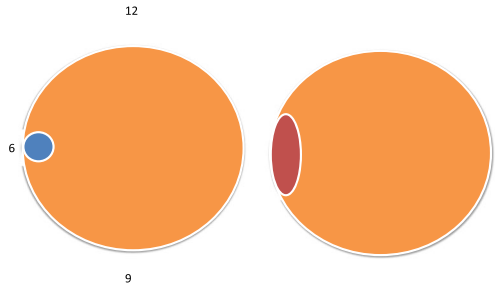

Figure 1 Brown color representing surgical specimen. Blue color representing epidermal margin affected. Red color representing deep margin affected

AR devices start to be used in the operating room, and the Israeli start-up Augmedics® has developed an augmented reality headset for spine surgeons with a technology that overlays a 3D model of the CT scan on the spine really close to the surgical field allowing the surgeon to focus on the field without the need to look at screens.[2]

In Mohs micrographic surgery (MMS), in Spain and other European countries, surgery is performed as teamwork (surgeon, pathologist, and technician). The Mohs surgeon performs

Figure 2 (a) After reading the fresh-frozen slide, the pathologist connects on the computer. On the screen, he can see a live image of the surgery that is being taken live with the webcam placed on the operating room. (b) The pathologist shares the fresh-frozen slide with the surgeons on the screen. (c) A webcam records the pathologist's finger over a white plain surface. Inset: The software superimposes the finger over the image on the screen that is being captured live in the surgery room. This way, the image can be seen on both screens, and pathologist and surgeon can talk over the image while discussing where the next excision should take place. (d) The pathologist can also draw over the image in order to exactly indicate where the margins are positive for tumor presence. (e) The pathologist can also use the mouse with different tools to discuss where the tumor is. In the image, the surgeon's finger (in a blue glove) can be seen pointing at the margin he is going to excise, and the pathologist is using an online scalpel to help him decide. (f) Surgeon watching on the screen his own hands over the surgical field along with the pathologist's superimposed finger with augmented reality

the stages while a trained pathologist reads them and informs the surgeon aided by drawings, telephone, text, or instant message applications. Many times the surgeon has to go to the pathology laboratory and check on the slides to fully understand the information about where to proceed with the next stage. The classic clock references are used in this process, but the pathologist frequently has to clarify whether the epidermal or the deep margin is affected as commonly used sentences such as "There is tumor present at 9" can be confusing and imprecise (Fig. 1). Also in "slow-Mohs" surgery, both in Europe and America, reports on the affected margins are written in the pathology report and can be confusing, even though precise drawings are used. The fact that the pathologist is physically away from the operating room, either in another floor or sometimes in another building, is time consuming.

We propose a novel use of AR in MMS, through the software *Proximie* ® (Proximie Ltd, London, UK), integrated by two devices (laptops, tablets, or phones) and two webcams; one of the webcams is on the surgical field and the other one is at distance focusing on a white plain surface where the hand is recorded live and superimposed on the surgical field. The screens of both devices show the merged image and also reproduce the live voice conversation allowing interaction of both physicians. It has already been successfully used to conduct remote surgeries.[3] We thought this system could improve the way the information is exchanged in MMS, as after the specimen arrives to the pathology laboratory and the slides are examined, the pathologist can use the AR software to exactly indicate where to proceed with the surgery, displaying his own finger or digital tools right over the surgical field and explaining to the surgeon where exactly the next stage should be performed (Fig. 2).

We think this small and low cost intervention could save time and improve communication in many MMS performed nowadays.

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