




## Correspondence

# Understanding the Biomechanical Properties of Skull Base Tissues Is Essential for the Future of Virtual Reality Endoscopic Sinus and Skull Base Surgery Simulators

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We would like to address the article titled “Virtual reality simulators for endoscopic sinus and skull base surgery: the present and future” by Kim et al. [1]. In the field of endoscopic sinus and skull base surgery (ESSBS), many virtual reality simulators (VRS) have been developed. The authors reviewed the current literature of these simulators and discussed the directions of future developments in a very interesting work. They focused on hardware, haptic devices, and software aspects. Consistently with the authors, we would like to emphasize the importance of haptic feedback development and to point out the current limitations of VRS in this field.

Haptic perception is defined as the combination of tactile perception and kinesthetic perception. In ESSBS, haptic perception is all the more important that tissues are not directly manipulated by the surgeon’s hands under direct vision, but by specific tools with indirect monitoring through an endoscope. As a result, depth perception and haptic feedback are reduced while

hand-eye coordination is disturbed [2]. A low-fidelity haptic feedback on VRS could lead trainees to applying abnormal forces when using surgical tools in real practice [3]. Similar issues have been described in robotic surgery where haptic feedback is lacking [2]. This can be dangerous in clinical practice because trainees could damage important functional or vital structures (i.e., internal carotid artery, optic nerves, meninges, orbits...) and lead to patient’s death or serious disability. Moreover, trainees are more comfortable and more accurate at characterizing tissues with simultaneous vision and haptic feedback than with visual feedback alone or haptic feedback alone [4].

Kim et al. [1] observed that most of ESSBS-VRS nowadays intend to provide haptic feedback. However, there are few data regarding the development and validation of haptic rendering. Indeed, to develop high-fidelity haptic tools, researchers need data on biomechanical properties of tissues, the most significant of which is the Young’s modulus. Unfortunately, data are lacking regarding skull base mechanical properties [5]: indeed, the Young’s modulus determination requires bending or tensile tests applied on multiple standardized formatted tissues samples. Yet the anatomy of the anterior skull base does not lend itself to standardized samples because of the frequent and large anatomic variations in bone thickness of the ethmoid and sphenoid paranasal sinuses, of the presence of multiple septa, and of its deep position within the head.

Realistic haptic feedback is crucial for the acquisition of surgi-

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cal skills. We are convinced that the future of high-fidelity ESS-BS-VRS development lies in fundamental research on biomechanical properties of skull base tissues. Meanwhile, simulation on cadavers or on validated synthetic simulators seems to be the adequate solution for training curricula in ESSBS.

### CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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