

## Placement of C2 laminar screws using three-dimensional fluoroscopy-based image guidance by Eric W. Nottmeier and Andrew B. Foy

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In their work colleagues Nottmeier and Foy present a retrospective series of eight patients treated with posterior C1–C2 fusion by laminar screws using three-dimensional fluoroscopy-based image guidance. They conclude from the results of their work that: “In this study, it has been shown that C2 laminar screws can be safely and accurately placed using 3D fluoroscopy-based image guidance. Advantages of this technology over traditional techniques include real-time 3D computerized feedback to the surgeon during placement, as well as the ability to size the screw to the patient’s anatomy using intraoperative computerized planning.”

In the last decade, technology has advanced to the point where regular computer workstations are able to calculate in real-time the transformation matrices needed to determine the position of a camera-tracked object (in a surgical setting, typically a frame with fiducials) in relation to a camera-tracked reference base. By attaching the reference base to a patient and (surgical) instruments to camera-tracked objects, the workstation can calculate the respective positions/orientations and display their virtual interactions. When three-dimensional data sets representing the patient’s anatomy from modalities including CT/MRI/3D rotational X-ray imaging, are manipulated so that virtual and real reference bases are exactly aligned, surgical instruments and/or implants can be displayed on anatomical structures not visible for the surgeon

intraoperatively. This is, in a nutshell, current “computer-assisted surgery” or “image-guided surgery”. Assuming that transformation matrix calculations are mathematical processes carried out with high fidelity and great reproducibility, imperfections in navigational accuracy must have other sources. Calibration errors in 3D fluoroscopy-based systems have, for example, been shown to account for approximately 1 mm accuracy in a phantom model [1]. In a more realistic cadaveric model, the accuracy of navigation deteriorated to approximately 2.5 mm, mainly due to bending of instruments and/or references during manipulation [2]. In clinical practice more inaccuracies can be introduced by occasional blocking of the camera field of view; inadvertently touching/hitting references and, especially, a nonrigid connection between the patient reference base and the actual surgical site. In the present study, the patient reference base was attached to a head clamp, which was, in turn, connected via pins to the patient’s skull while surgery was performed at the levels C1 and C2. This experimental setup represents quite a long chain of connections from the reference base to the surgical site with considerable opportunity for movement between the two extremes. This is without taking into account additional movements due to, for example, patient ventilation and direct manipulation of C1 and C2 by surgical instruments. Considering that the C0–C1–C2 complex is highly mobile, it came as a small surprise for this reviewer to find such accurate screw placement in the current study. As can be found in the article, the investigators did verify the image-guided technique (“After accuracy of navigation was confirmed by the surgeon ...”). The interesting question that follows automatically is: “How?” Checking accuracy by probing the patient reference base with a navigated instrument and finding a perfectly matched position/orientation on the computer display does nothing for the

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flexibility/movement errors that may be present at the more distant surgical site. Most often, surgeons verify accuracy by a direct intraoperative view of the surgical site to see whether, for example, the proposed drill trajectory or planned screw length is in accordance to their own experience from conventional surgeries before moving on with navigation. This leads to the strange paradox that is really bugging contemporary image-guided procedures: the employment of a technique to enhance surgical accuracy *requiring the surgeon's intraoperative verification of its accuracy*. The reluctance of surgeons to show complete faith in image guidance seems justified considering the errors demonstrated in accuracy studies. Using computer navigation without proper anatomical and surgical knowledge would be irresponsible. Armed with proper knowledge, however, navigation becomes largely superfluous since surgeons trust their surgical experience/skills and the direct intraoperative view over computer-generated images anytime, and adjust their actions accordingly. Which surgeon would happily volunteer when asked to perform a percutaneous procedure having to trust *solely* on information provided by any image-guided technique commercially available today?

Until now, no large-scale long-term and *properly controlled* study has been published in the field of computer-assisted surgery that has convincingly showed any actual *patient benefit* when using image guidance. Lacking a control group and using a navigation technique susceptible to the aforementioned accuracy problems, the present study may, unfortunately, not be able to change this status.

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