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The three-dimensional difference: Craniovertebral junction unveiled

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> *"Touch comes before sight, before speech. It is the first language and the last, and it always tells the truth."*
>
> *-Margaret Atwood*

The Webster dictionary defines the third-dimension (aka depth) as a dimension that adds the effect of solidity to a two-dimensional (2D) system. Do we see the world around us in 2D or in 3D? The human eye can perceive only two dimensions of an image that is projected on the retina. To see a 3D world, we would actually have to be four-dimensional human beings. Hence, how do we see around us in three-dimensions? The answer is that our visual cortex is wired to read cues such as shadows, parallax, relative size and position, and stereoscopic vision which are interpreted by our nervous system as a 3D image. Parallax from the Greek word "parallaxis" meaning alteration is a difference in the apparent position of an object viewed along two different lines of sight. The principle of parallax is used in optical instruments such as the microscope, which we as neurosurgeons use on a daily basis, and provides us with the impression of 3D. Human beings like many animals have two eyes and use overlapping visual fields that use parallax to gain depth perception and perceive a 3D image. This process is known as stereopsis. Thus, we see the world in two and a half dimensions that is 2D plus depth making it 3D.

Touch provides information for creation of perceptual representations of the milieu around us. 3D objects which can be held, manipulated, and rotated in our hands enhance the impression of the 3D structure that we are trying to build in our nervous systems.

3D-printed models provide us with this additional dimension and perception, which we were earlier only imagining in our craniums with the help of 2D images available from the patient's CT or MRI.

> *"Real anatomy exists in three-dimensions so any time you can view anatomical data in 3D, you'll have a much more accurate picture of the subject… even multiple two-dimensional images can never allow you to understand a Subject's anatomy as quickly or as accurately as a quality 3D visualization."*
>
> *-Paul Brown*

Surgery for alterations at the craniovertebral junction is a daunting task. The bony architecture of the craniovertebral junction houses the delicate cervicomedullary cord. Inadvertent injury during surgery can leave a patient alive but helpless and dependent unable to move or breathe. The major perils of surgery in this region are the distorted bony anatomy of the region and the sometimes-anomalous course of the vertebral artery. Both these hazards can be overcome by having the image of the bony and vascular anatomy in front of your eyes before and during surgery. 3D-printed patient-specific models of the region serve as invaluable aids to overcome this double jeopardy.[1]

The 3D model can be held, visualized in all dimensions, swiveled around till the image is imprinted in the memory [Figure 1]. Moreover, it can be placed beside the patient during the surgery in the precise surgical position to be referred to if necessary. The whole operation can be rehearsed before the actual enactment of the surgery. The model also serves as a teaching tool for both patients and neurosurgeons in training. As the model is of actual patient size, the sizes of the implants can be precalculated and the trajectories of the screws can be planned. The model shows the exact traverse of the vertebral artery and also its dominance thus making it possible to keep it out of harm's way. The shape, inclination, and orientation of the facets can be accurately visualized. In patients with torticollis, the model assists in determining which side to approach first. Thus, the model can provide a clear feel of the altered anatomy in a 3D perspective rendering confidence to the surgeon and making the surgery easy.[1]

Figure 1

Three-dimensional model showing a craniovertebral junction abnormality. The alignment of the facets can be clearly visualized. The course, location, and dominance of the vertebral arteries can be appreciated

In conclusion, although 3D reconstructed images give an overall view of the anatomy of the region – a 3D model is far superior and closer to real time. The information can even supersede virtual simulation. Thus, 3D models can be an invaluable aid during surgery for complex craniovertebral junction anomalies.

> *"Learn anatomy not from books, but from dissections, not from the tenets of Philosophers but from the fabric of nature."*
>
> *-William Harvey*

Although a 3D model cannot replace anatomical dissections, it may be the next best thing to study patient-specific anatomy.

Reference

Go to:

1. Goel A, Jankharia B, Shah A, Sathe P. Three-dimensional models: An emerging investigational revolution for craniovertebral junction surgery. J Neurosurg Spine. 2016;25:740–4. [PubMed]