USC Norris Comprehensive Cancer Center: Discovering Hidden Data With PACS-embedded Advanced Visualization

BY CHERYL PROVAL

Having a tool kit of advanced visualization tools embedded in the PACS of the Keck Hospital of the University of Southern California (USC) has touched every aspect of the practice of Vinay Duddalwar, MD, FRCR. As abdominal-imaging section chief and director of the USC Norris Comprehensive Cancer Center (NCCC) imaging department, Duddalwar reports that there no longer is a problem getting reformatted studies into the PACS. This enables surgeons to view 3D reconstructions on 70-inch screens in the operating room as they work.

In his personal practice, Duddalwar enjoys the ease of obtaining tumor volumes for liver-resection patients, a formerly time-consuming process that now takes minutes, with the embedded fusion and registration tools at his fingertips—not at the workstation across the room. A supplemental—and perhaps more promising—benefit, as the NCCC radiologists explore the tool set, is being able to get at what Duddalwar calls a study’s hidden information. This has already generated a number of new clinical applications, with presumably more yet to be discovered.

“We’ve always found that there is a lot more information on imaging—be it CT or MRI—that is almost hidden,” he explains. “We don’t really use all of the information (such as some aspects of applied functional information) that is available, but difficult to extract.”

“We are using the advanced visualization tools in order to extract more and more information that actually makes a difference in the way the surgeons approach a surgery.”

—Vinay Duddalwar, MD, FRCR

USC Norris Comprehensive Cancer Center

One of the key clinical applications of advanced visualization that Duddalwar and colleagues have explored, since taking delivery of the 3D Clinical Application Suite embedded in the Synapse PACS from FUJIFILM Medical Systems USA, Inc, a year ago (with enhancements in September 2012) has been working with surgeons on their approach to renal masses. At this world center for partial nephrectomy, USC surgeons take a laparoscopic approach to most resections, and the radiologists work to provide what Duddalwar describes as a roadmap of what they will see during the surgery.

“In fact, we try to give them almost a trial run with our visualizations, so that if they dissect this patient, this is what they are going to see,” he explains. “We work very closely with them.”

What’s more, Duddalwar and his team are providing surgeons with prognostic information intended to anticipate problems that might be encountered in a renal resection and that might help predict functional outcomes for the patient after surgery; these successes have been shared by Leslie et al at urology meetings in 2012.1,2 “We are measuring the volume of the remaining kidney, and we discuss, with the urologist, what the margin of resection would be or could be; we then try to define how much of a functional loss the patient will have,” Duddalwar explains.

The tools used in this application primarily are volume rendering and fusion. The radiologists use the Synapse fusion tool to fuse multiple phases of imaging, such as the vascular and the arterial phases of the study, which are then fused with the tumor to understand the tumor’s relationship with the venous
and arterial systems. “We are using this information to predict that, for example, we are going to be taking a slightly longer time with this surgery,” Duddalwar says.

**Additional Applications**

The advanced visualization tools also are being used to differentiate among various types of renal masses and how they respond to selected chemotherapies. “This is a work in progress, and we are applying it in various ways,” Duddalwar notes. “Some of these patients with tumors get different chemotherapies, and we are analyzing the way that the tumor changes, using the advanced visualization tools. Predominantly, we are monitoring the changes in density and perfusion.” A pixel-mapping tool is being used to characterize fat in tumors.

Patients are referred to NCCC with imaging studies from many other locations, so tumor tracking can be challenging. The radiologists at NCCC are beta testing a new Synapse tool called Response Evaluation Criteria in Solid Tumors (RECIST) tracker, which assists them in monitoring tumor progression using the RECIST measurements. “It is often difficult to be very objective about these things, but we do use those tools to register the old scans to the new scans, to be certain that this is the lesion that we are following, that this is the change that is happening, and (during a period of six months) that there is a growth of 30% or a decrease in size of 20%, and so forth,” Duddalwar says.

The tool that has proven indispensible to the oncologic imagers is the fusion tool. “Some of these patients have lesions that are seen on a PET scan that may have been done elsewhere, and we need to know that they are the same lesions seen on a CT exam here,” Duddalwar explains. “We fuse all of these studies; the fusion tool is used pretty much throughout the whole day.”

**Impact on Workflow**

Having the tools embedded in Synapse has had a marked impact on radiologist workflow, Duddalwar says. “Previously, we had to go to a stand-alone workstation to process the images—and then, it was difficult to transfer them back, either to the PACS or into a format that our surgeons could use,” he explains.

Radiologists are both processing the images themselves and working with technologists in the 3D laboratory to cross-check and collaborate on how to process certain images that will be transferred to Synapse (to be available, for instance, to surgeons in the operating rooms). “They have all of these vascular maps, which we’ve devised in formats after multiple consultations with them,” he explains. “They actually project these on giant 70-inch screens in the operating room to have them in front of them while they are operating.”

Radiologists at NCCC have been working with the tools for a year, but took delivery, in September, of an enhanced and improved version of the advanced visualization tool set that is more intuitive than the previous version. “It’s a matter of working with the development people to see if there is a better way of achieving what we want,” Duddalwar says. “Sometimes, they learn from us, and sometimes, we learn from them; it’s a bidirectional process. There are lots of tools that we haven’t explored completely. Our work is driven primarily by what the clinical questions are.”

Over the course of the past year, with ready access to advanced visualization, the USC radiologists are using the tools “pretty much all of the time,” Duddalwar says. “The more my colleagues and I get comfortable with the set of tools, the more applications we find, and the more we are using them.”

Cheryl Proval is the editor of Radinformatics.com.

**References**


Imaging can play a valuable role in the early diagnosis of dementing disease. In a special-interest session held on November 26, 2012, at the annual meeting of the RSNA in Chicago, Illinois, neurologist Norman Foster, MD, copresented “What Imaging Measurements Are Needed in Clinical Practice?” He explains how imaging can increase physician confidence and accuracy in the diagnosis and prognosis of dementing disease through identification of biomarkers on imaging studies.

According to Foster—professor of neurology at the University of Utah, senior investigator at the university’s Brain Institute, and director of its Center for Alzheimer’s Care, Imaging and Research—early identification of Alzheimer disease and other dementing diseases is critical in preparing patients and their families for dramatic lifestyle changes. Accurate prognosis will enable patients to make the necessary modifications to their lifestyles.

The problem with dementing disease, Foster says, is that primary-care physicians are reluctant to address memory issues with their patients and lack confidence in their ability to make accurate diagnoses. Uncertain diagnoses and inconclusive evaluations can lead to frustration, inconsistent treatment, and continued confusion for both patient and physician.

Brain imaging has been an accepted part of diagnosis since 2001, and the American Academy of Neurology’s practice parameters include structural neuroimaging as part of the routine for patients with dementing disease, Foster notes. There are now validated, quantitative imaging biomarkers for dementing disease, and it is possible to predict outcomes for patients with mild cognitive impairment.

Three Stages

The US National Institute on Aging (NIA), in conjunction with the Alzheimer’s Association, released new criteria, earlier this year, for diagnosing Alzheimer disease. Diagnosis of Alzheimer disease is broken into three recognizable stages: preclinical disease, mild cognitive impairment, and symptomatic dementia.

In mild cognitive impairment, mild changes in memory and thinking are noticeable and can be measured on mental-status tests, but aren’t severe enough to disrupt a person’s day-to-day life, according to the NIA guidelines. In symptomatic dementia, impairments in memory, thinking, and behavior significantly affect a person’s ability to function independently in everyday life.

Preclinical Alzheimer disease is a newly recognized stage of the disease, Foster explains. In this stage, key biological changes occur in the body, but the disease has not yet caused any noticeable clinical symptoms (such as mild cognitive impairment). According to the NIA guidelines, current scientific evidence suggests that in preclinical Alzheimer disease, brain changes caused by the disease might begin years (or even decades) before symptoms such as memory loss and confusion become evident. These changes can be detected through the presence of biomarkers.

Biomarkers are measurable benchmarks in the body that indicate the presence or absence of a disease (or the probability of developing a disease). For Alzheimer disease, Foster says, the strongest biomarker candidates include changes seen in brain-imaging studies using MRI or PET and the presence of specific proteins in the cerebrospinal fluid.

Collecting the Evidence

Diagnosis with high levels of probability and accuracy depends on quantitative evidence observed in imaging studies, Foster says. This is found by comparing patients’ exams to those with patterns characteristic of Alzheimer disease.

On MRI exams, for example, physicians can look for patterns typical of Alzheimer disease, particularly hippocampal atrophy. Hippocampal volume can be measured on MRI, and if it is significantly less than expected for age and there is in-
creased ventricular size, then it becomes a very strong indicator of Alzheimer disease. Foster uses NeuroQuant® software (Cortechs Labs). [Jeanie: Do you want me to remove this?]

Molecular imaging can also help identify the preclinical stages of dementing disease. In an example from Foster, a radiologist looking at transaxial images has to decide whether there’s enough hypometabolism in the posterior temporoparietal cortex to consider it abnormal (as opposed to consistent with normal variation). With quantitative techniques such as stereotactic surface-projection maps, these determinations become more concrete and data driven.

Stereotactic surface projection allows for comparison of a particular individual’s pattern of metabolism with other datasets, such as those of subjects with normal cognitive function. With these quantitative measures, physicians can determine whether there are statistically significant levels of hypometabolic activity (an indication of developing dementia).

**Failure to Report**

Despite these advances, imaging, thus far, has not provided this kind of information to physicians, according to Foster. The problem isn’t one of capability, Foster notes. Imaging can play a pivotal role in the diagnosis of dementing disease, and Foster observes that physicians’ confidence and accuracy levels differ before and after imaging. Before imaging, there is low confidence in diagnosis and the probability of misdiagnosis is high, he says, but after imaging, these results improve significantly, boosting both confidence and accuracy.

The newly defined preclinical stage of Alzheimer disease will become more important if researchers can develop treatments that slow or stop the progression of Alzheimer disease—treatments that might be most effective if used as early as possible in the course of the illness. Physicians are looking to radiology and imaging for help in identifying the specific causes of dementia, Foster says. With accurate prognosis, patients can better prepare for long-term–care solutions. Imaging is critical for early diagnosis, but it is failing to meet its potential. Foster hopes that radiologists and other physicians can work together to provide more diagnostic confidence and accuracy using quantitative biomarker clinical analysis.

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**Reference**

Advanced visualization technology in imaging continues to garner acceptance within the radiology arena, yielding improvements in practice patterns and opportunities for enhanced cooperation with clinicians. Sanjay Prabhu, MBBS, FRCR, is a staff radiologist at Boston Children’s Hospital in Massachusetts and director of Boston Children’s Advanced Image Analysis Laboratory. He says that advanced visualization has, indeed, dramatically changed radiologists’ practice patterns, in part because the detail level of 3D models has rendered radiologists significantly more confident about the accuracy of their interpretations.

“The key is to tweak and tailor; otherwise, you construct unnecessary barriers to technology adoption. The way I see it, as a superuser, I don’t need to give everyone all the recipes—just the four they want to eat. Otherwise, they will get indigestion.”

—Sanjay Prabhu, MBBS, FRCR, Boston Children’s Hospital

As radiologists acquire more ready access to advanced visualization tools on their desktops, they are becoming more inclined to avail themselves of the department’s advanced visualization arsenal. To illustrate this point, Prabhu cites the example of a patient with a skull fracture. In the past, he explains, a radiologist would be presented with, at best, 2D images of the skull, but would need to wait until the following day for the laboratory to produce a reconstruction model.

“Under the old system, we were talking about a 10-hour wait, but by having the visualization tools at our fingertips, we can now, during the daytime, see immediately and at a glance what has happened and have a visual to show to the parents, usually within one hour,” Prabhu says. “With 3D models at our fingertips at the time of reporting, we know we aren’t speculating about maybe a crack here and a crack there or whether, if we are going with the example of the skull, something looks different from one angle than from another.”

Adding Subspecialist Value

Subspecialists can enhance their practices with 3D imaging applications. Neuroradiologists, Prabhu points out, can use data produced during MR diffusion tractography to generate 3D maps of neural tracts within the brain.

“With a conventional MRI image, the white matter looks like a single homogenous-looking area, and from far away, you cannot see small breaks or flaws,” he elaborates. “Conversely, with diffusion tractography, a neuroradiologist can see whether there are breaks or displacements of the tracts within the white matter, and potentially provide useful information in the situation of a child with a developmental delay or seizures whose brain looks structurally normal on plain MRI.”

Moreover, cooperation between radiologists and clinicians has become smoother than ever before. Clinicians appreciate the fact that they can harness visuals and associated information to plan their surgical approaches precisely and ensure that they are approaching procedures in the proper manner. For instance, Prabhu observes, there is no guesswork as to the length of an aorta, how the skull will look after the surgeon does something, or the volume and blood supply of a tumor.

Addressing Adoption Challenges

With these benefits, however, have come challenges. According to Prabhu, advanced imaging has garnered a higher degree of acceptance among clinicians who are simply more comfortable with traditional radiology reporting solutions. Conversely, those who have grown up with all types of technology view 3D as just another innovation to use in the course of practice.

“The key is to tweak and tailor; otherwise, you construct unnecessary barriers to technology adoption,” Prabhu says.
“The way I see it, as a superuser, I don’t need to give everyone all the recipes—just the four they want to eat. Otherwise, they will get indigestion.”

The Evolution From 2D to 3D

Prabhu adds that as radiologists have transitioned away from 2D viewing to 3D viewing, what they are looking for has changed. They place great value on the level of dimensional detail visible with 3D modeling, and they now want the flexibility needed to satisfy clinicians’ desire for visuals that are easier to understand and use for their own purposes (for instance, when plotting their surgical approaches).

Prabhu is currently striving to refine Boston Children’s Hospital’s advanced visualization capabilities; he is attempting to make it possible to generate diagnostic 3D bone reconstruction models for images acquired with reduced radiation doses. “The MRI piece is a work in progress,” he concludes. “There are still questions to answer, but we’ve come very far, as a whole, and I think we will get there.”

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