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Using AI to predict bone fractures in cancer patients

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As medicine continues to embrace machine learning, a new study suggests how scientists may use artificial intelligence to predict how cancer may affect the probability of fractures along the spinal column.

In the U.S., more than 1.6 million cases of cancer are diagnosed every year, and about 10% of those patients experience spinal metastasis—when disease spreads from other places in the body to the spine. One of the biggest clinical concerns patients face is the risk of spinal fractures due to these tumors, which can lead to severe pain and spinal instability.

"Spinal fracture increases the risk of patient death by about 15%," said Soheil Soghrati, co-author of the study and associate professor of mechanical and aerospace engineering at The Ohio State University. "By predicting the outcome of these fractures, our research offers medical experts the opportunity to design better treatment strategies, and help patients make better-informed decisions."

While many of the changes the body undergoes when exposed to cancerous lesions are still a mystery, with the power of computational modeling, scientists can get a better idea of what's happening to the spine, said Soghrati.

Their study, published in the *International Journal for Numerical Methods in Biomedical Engineering*, describes how the researchers trained an AI-assisted framework called ReconGAN to create a digital twin, or a virtual reconstruction of a patient's vertebra.

Unlike 3D printing, where a virtual model is turned into a physical object, the concept of a digital twin involves building a computer simulation of its real-life counterpart without creating it physically. Such a simulation can be used to predict an object or system's future performance—in this case, how much stress the vertebra can take before cracking under pressure.

By training ReconGAN on MRI and micro-CT images obtained by taking slice-by-slice pictures of vertebrae acquired from a cadaver, researchers were able to generate realistic micro-structural models of the spine. Using their simulation, Soghrati's team was also able to virtually enlarge the model, a capability the study says is imperative to understanding and incorporating changes into the entirety of a vertebra's geometric shape.

"What really makes the work in a distinct way is how detailed we were able to model the geometry of the vertebra," said Soghrati. "We can virtually evolve the same bone from one stage to another."

In this case, the researchers used CT/MRI scans from a 51-year-old female lung cancer patient whose cancer had metastasized to simulate what might happen if cancer weakened some of the vertebrae and how that would affect how much stress the bones could take before fracturing.

The model predicted how much strength parts of the vertebra would lose as a result of the tumors, as well as other changes that could be expected as the cancer progressed. Some of their predictions were confirmed by clinical observations in cancer patients.

For a field like orthopedics, using a non-invasive tool like the digital twin can help surgeons understand new therapies, simulate different surgical scenarios and envision how the bone will change over time, either due to bone weakness or to the effects of radiation. The digital twin can also be modified to patient-specific needs, Soghrati said.

"The ultimate goal is to develop a digital twin of everything a surgeon may operate on," he said. "Right now, they're only used for very, very challenging surgeries, but we want to help run those simulations and tune those parameters even more."

But this was just a feasibility study and much more work is needed, Soghrati said. ReconGAN was trained on data from only one cadaveric sample, and more data is needed for AI to be perfected.

More information: Hossein Ahmadian et al, Toward an artificial intelligence -assisted framework for reconstructing the digital twin of vertebra and predicting its fracture response, *International Journal for Numerical Methods in Biomedical Engineering* (2022). DOI: 10.1002/cnm.3601

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