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Investigation of artificial defects of BSCC heart valves using radiographic computational methods

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X-ray imaging systems are among the oldest and most widely used imaging systems in medical and industrial diagnostics. X-ray imaging systems have changed considerably over the course of their existence. The physical principle remains unchanged, but the technical means of image acquisition have been replaced. Today, in addition to conventional X-ray imaging machines, digital machines and CT tomography systems are used. X-ray systems are not only used in the medical field, but also in engineering for the purpose of identifying defects in materials and so on. CT systems are characterized by a fundamentally different way of processing data compared to conventional and digital X-ray, even though their common feature is imaging using X-rays. X-ray imaging produces a two-dimensional summation image, whereas CT systems display slices, so-called tomographic planes. If enough of these planes are created using the CT machine, a three-dimensional model of the scene can be created with the aid of computational technology. In addition to 3D imaging, the importance of computed tomography lies in the higher contrast of the imaged object compared to X-rays and provides higher spatial resolution. The CT scan is performed by placing the patient in a machine (gantry) consisting of an X-ray tube and a detection system. The resulting image is reconstructed from the detected data using an appropriate mathematical algorithm and then displayed on the screen as a set of points called voxels. As the radiation passes through the tissues, its rays are attenuated differently, which allows the individual structures of the imaged area to be distinguished in the resulting image.
The Björk-Shiley convex-concave implant represented a modern and advanced model of heart valve replacement in its time. The design consists of an inlet and outlet strut fixed on a rim, between which a disc-shaped occluder disc is inserted. The struts, or separate protrusions, pointing into the valve opening provide anchorage and guidance of the movable disc. The implant consists of a single disc coated with carbon and housed in a rim made of Haynes 25 alloy consisting of 51% Co, 20% Cr, 15% W and 10% Ni. Individual measurements aimed at detecting inhomogeneities in the Björk-Shiley convex-concave valve implants (BSCC) were performed at the Kysuce Hospital with Polyclinic in Čadca (Slovakia). Digital X-ray and computed tomography measurements were performed at the Department of Radiology aiming at the radiographic detection of destructive changes in the BSCC mitral valve struts. The resulting images were evaluated as 2D native tomograms and later reconstructed into 3D structures. The resulting 3D images were processed in the original GE Healthcare software and the Slicer environments, and the results were compared. At the same time, measurements were made leading to the detection of inhomogeneities using the eddy current method, which, if used, would represent an invasive, but at the same time very effective and accurate method, also helpful in detecting minor destructive changes in the valve orifice, which, if indicated late, can lead to the complete dysfunction of the implant and the possible death of the patient. Each measurement dealing with the description of artificial material inhomogeneity consisted of imaging structures with and without a simulated crack in the given samples. On the sensing pad, the valves were ranked according to the degree of damage located at the outlet strut, representing this implant's leading cause of dysfunction. The individual valves were arranged as follows: - valve 0 - the absence of an artificially created notch (so-called intact sample), valve 1 - shallow notch in the outlet strut near the rim, valve 2 - notch up to half the thickness of the outlet strut, valve 3 - the deepest notch in the outlet strut of the valve simulating the condition before the detachment of part of the strut.

Author: SMETANA, Milan (DEBE, FEEIT, UNIZA)

Co-authors: GOMBÁRSKA, Daniela; Mr DURCO, Martin

Presenter: SMETANA, Milan (DEBE, FEEIT, UNIZA)

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