Medical Imaging Characteristics of Silicon Nitride Ceramic

A New Material for Spinal Arthroplasty Implants

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Objectives

Compare the clinical visibility of identically sized samples made of different materials in a single cadaver human vertebral body under identical imaging settings.

Methods

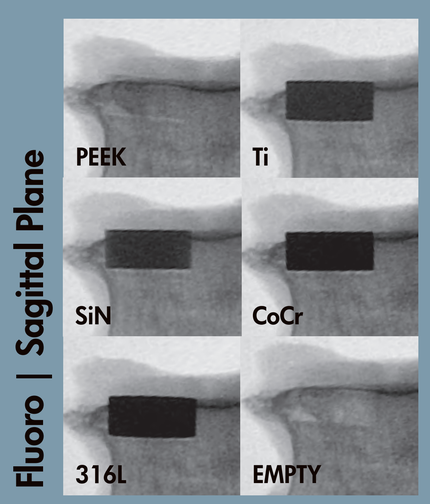
Intervertebral disc and soft tissues were removed from a single cadaveric human L4 vertebral body. A 15mm diameter hole was bored through the anterior margin of the superior endplate to a depth of 8mm. Cylinders 15mm in diameter and 7mm thick made of stainless steel (316L), cobalt chromium (CoCr), Polyetheretherketone (PEEK), commercially pure titanium (Ti), and silicon nitride ceramic (SiN) were sequentially inserted into the hole in the vertebral body. Axial and sagittal plane images of the vertebral body were collected using fluoroscopy, CT and MR. All imaging settings were held constant as cylinders were changed.

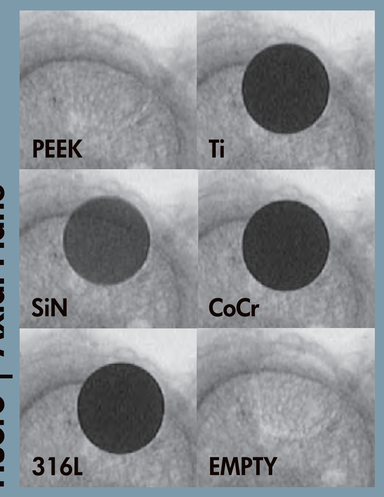
Radiolucency of the cylinders under fluoroscopy was assessed by measuring the greyscale brightness of the anterior cortical wall underlying the cylinder. The area of the vertebral body obscured by distortion under MR was quantified by calculating the ratio of the diameter of field distortion vs. actual cylinder diameter. The presence of scatter in the CT images was noted and qualitatively graded.

L4 Cadaver Vertebra with Implanted CoCr Test Cylinder

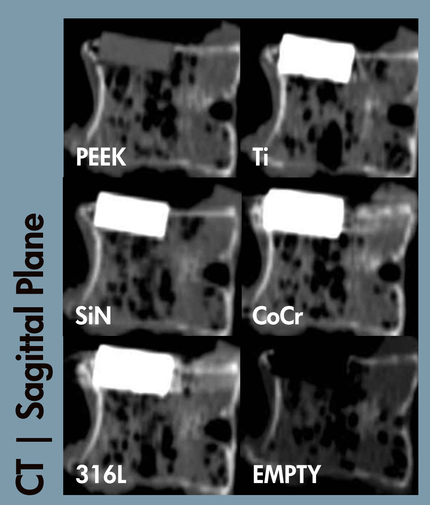
Results

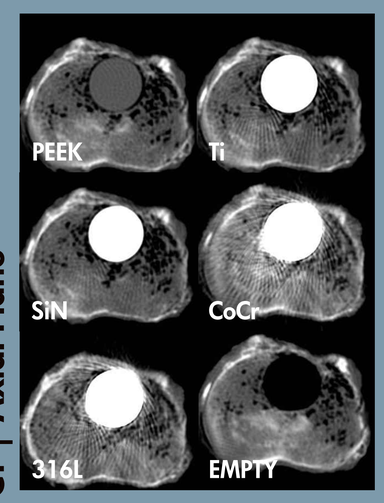
In fluoroscopic images, the anterior cortical wall was not visible under the 316L, CoCr and Ti cylinders. The PEEK cylinder was completely invisible, the cortical wall had a brightness of 38%. The cortical wall was visible underneath the SiN cylinder and had a brightness of 14%. Under MR, the area of distortion ratio of the 316L, CoCr, and Ti cylinders was 3.1, 2.2, and 1.4 respectively. The PEEK and SiN cylinders exhibited no distortion. Significant scatter in CT images was noted for the 316L and CoCr cylinders, and minor scattering with the Ti cylinder. The PEEK and SiN cylinders exhibited no scattering.



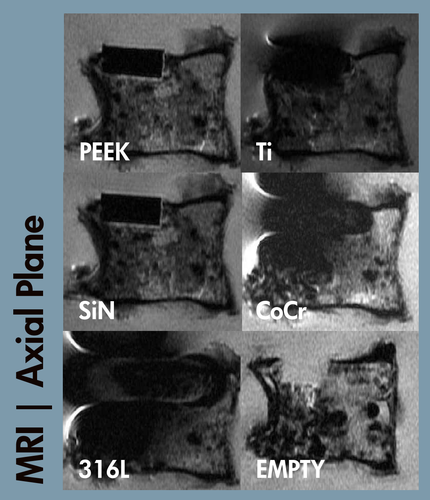


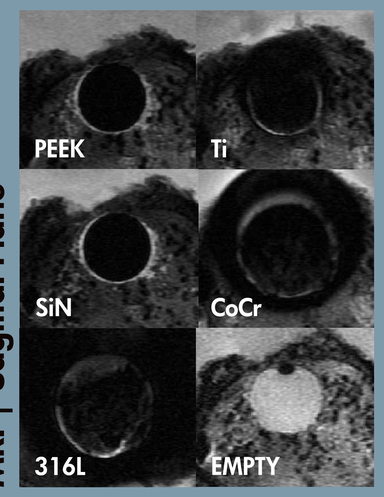
Cortical Rim Gray Value	
38%	0%
14%	0%
0%	38%





CT Scatter	
None	Minor
None	Major
Major	None





Distortion Ratio	
0	1.4
0	2.2
3.1	N/A

Conclusions

Material selection can contribute to, or impede postoperative monitoring of spinal surgery. It is desirable to visualize both an implant's position and the surrounding bone and soft tissues. Considering the cylinders as analogs to a spinal implant, , 316L, CoCr, and Ti cylinders were visible under fluoroscopy but precluded visualizing underlying bone, while the PEEK cylinder was completely invisible. The SiN cylinder and underlying bone were both visible. Under MR imaging, distortion surrounding the 316L, CoCr, and Ti cylinders would preclude monitoring the position of, or growth of bone around an implant. The PEEK and SiN cylinders exhibited no distortion. The combination of partial radiolucency under fluoroscopy, no distortion under MR, and no scattering under CT may facilitate postoperative monitoring of implants made of SiN ceramic.

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