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Abstract

Design and 3D printing of novel Ti spine rods with lower flexural modulus/stiffness with optimized imaging compatibility

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To manufacture and test 3D printed novel design titanium spine rods with lower flexural modulus and stiffness compared to standard solid titanium rods for use in metastatic spine tumour surgery (MSTS) and osteoporosis.

Novel design titanium spine rods were designed and 3D printed. Three-point bending test was performed to assess mechanical performance of rods, while a French bender was used to assess intraoperative rod contourability. Furthermore, 3D printed spine rods were tested for CT & MR imaging compatibility using phantom setup.

Different spine rod designs generated includes shell, voronoi, gyroid, diamond, weaire-phelan, kelvin, and star. Tests showed 3D printed rods had lower flexural modulus with reduction ranging from 2 to 25% versus standard rod. Shell rods exhibited highest reduction in flexural modulus of 25% (~ 77.4 GPa) and star rod exhibited lowest reduction in flexural modulus of 2% (100.8GPa). 3D printed rod showed reduction in stiffness ranging from 40 to 59%. Shell rod displayed highest reduction in stiffness of 59% (179.9 N/mm) and gyroid had least reduction in stiffness of 40% (~ 259.2 N/mm). Rod bending test showed that except gyroid, other rod designs demonstrated lesser bending difficulty versus standard rod. All 3D printed rods demonstrated improved CT/MR imaging compatibility with reduced artefacts versus standard rod.

By utilising novel design approach, we successfully generated a spine rod design portfolio with lower flexural modulus/stiffness profile and better CT/MR imaging compatibility for potential use in MSTS/other conditions such as osteoporosis. Thus, exploration of new rod designs in surgical application could enhance treatment outcome and improve quality of life for patients.

AUTHOR'S STATEMENT

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