ABSTRACT
Currently, osteomyelitis is treated with PMMA beads loaded with antibiotics, which has the disadvantage that a second surgery is needed and the defect has to be reconstructed with a bone graft material to stabilize. A biomaterial with beneficial properties for osteomyelitis treatment is S53P4 bioactive glass granules. These granules are biodegradable, so a second surgical intervention is not needed. Besides, the granules inhibit bacterial growth, stabilize the defect and stimulate formation of new bone.
S53P4 bioactive glass has already been used in treatment of osteomyelitis and shows positive results compared to treatment with gentamicin-PMMA beads. The granules have a low fracture toughness and brittleness that are not favorable properties to use the granules in load-bearing defect. However, previous studies show that the granules could tolerate high load. Clinical use of the granules in load-bearing defects show not all positive results; in one case fracture occurred at the treated site nine days after surgery. It is still unclear if the stiffness of the glass granules is the reason of fracture or that there is another reason (e.g. the size of the cortical window).

To determine if bioactive glass granules are able to restore the bending stiffness of a bone with cortical window, an FE model has been developed and validated that could represent the different stages (intact bone, bone with defect and grafted bone) of treatment of osteomyelitis with bioactive glass granules. This model can predict the bending stiffness of the bone and is validated by experimental four point bending tests (n=7). The four point bending experiment showed that creating a cortical window results in a significant decrease of the bending stiffness of the bone, and that the granules are able to restore the bending stiffness of bone to the pre-operated stiffness. However, the FE model was only able to predict the normalized change of the bending stiffness as a result of the cortical window ($R^2 = 0.924$). The model was not fully able to estimate the restoration in bending stiffness as a result of grafting the defect. In conclusion, the FE model has to be improved before it is able to describe the bending stiffnesses of the different stages during osteomyelitic treatment.

Besides the mechanical properties, we were interested in the influence of an in-vivo environment on the S53P4 bioactive glass granules. Most of the information about the in-vivo behavior of S53P4 bioactive glass granules is obtained from in-vitro studies or animal studies, and for the human clinical situation the information is based on in-vivo imaging techniques.
Granules retrieved from a patient after two years in-vivo, provided an unique opportunity to get detailed information about the composition and structure of the grains after this time period. To detect the loss of the volume of the granules after 2 years in-vivo, the removed granules (n=30) and control granules (n=26) from the same batch were scanned with micro-CT and the volume of the granules was determined. No significant difference between the volume of the removed and unused granules could be determined, however based on the results an estimation could be made about the degradation rate; 10% volume loss a year. Furthermore, the change in chemical composition and structure at the surface of the granules was investigated. With use of SEM the structure of the surface and a cross-section of the granule was imaged, and with EDX the chemical composition of the surface was determined. Results show that after two years in-vivo around the granule layers are formed with different structure and composition than the granule itself. Further research is needed to investigate the exact composition of these layers. For instance histology could be used and an EDX spectrum of the cross-section of the granule could be made.