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Abstract

Characterization of bone-implant interfaces by application of a combined force- and acoustic emission (AE) measurement testing process

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For orthopedic implants, evaluating the long-term stability of the bone-implant interface (equaling osseointegration) is decisive for patient safety. In implant development, surface properties, material or structuring are adapted to reach successful patient treatment and stable osseointegration. Therefore, implants are inserted into animal bone *in vivo* and pushed-out after a recovery phase of e.g. eight weeks [1] for determination of stability. However, total shear strength limits information to the final timepoint of failure and neglects initial signs of loosening. To include initial signs of loosening, acoustic emission (AE) testing is a promising candidate. We thus develop a test stand with combined force and AE testing for characterization of a variety of materials and bone-implant interfaces based on [2].

The test stand (max. load 2500 N) features push-out capability and an AE wideband sensor (100-1000 kHz) for microcrack monitoring [2]. The adaptable specimen grip allows for testing of various implant types. AE-testing detects microscopic defects by analyzing emitted energy during crack formation. AE-hits are documented, correlating with force and axial displacement to characterize bone-implant interfaces. Tests on 3D-printed structures assessed macroscopic crack formation, confirming the test stand's concept. Initial microscopic crack analysis used a custom bone-implant model with a screw in (a) sawbone and (b) pork ribs.

Analysis of macroscopic cracks on 3D-printed materials provides proof-of-concept and displays a characteristic course. Allocation of hits to timepoint and load could be achieved leading to high potential for further material characterization and a reproducible testing process. Microcracks could be differentiated from macroscopic crack initiation. We could identify a clear correlation of load to AE data and achieve first systematic testing of different models, paving the way towards osseointegration evaluation in combined testing for early implant development.

AUTHOR'S STATEMENT

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