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SUB-MILLIMETER-SIZE OPTO-MECHANICAL COUPLINGS FOR FAST ROTATIONAL OCT-SCANNING

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ABSTRACT

INTRODUCTION Optical Coherence Tomography (OCT) is increasingly being applied in small-diameter instruments, like catheters, bone drills, and steerable needles. For such applications, a rotary scanning motion is usually most feasible and/or desired, making coupling the light from the stationary OCT light source into a rotating part a common design issue. Coupling light between rotating optical parts is especially challenging due to the very strict demands on tolerances and alignments. We developed two optical couplings for high-speed (2000 rpm) rotational OCT that are applicable in instruments with diameters below 1 mm. The goal of the current research is to evaluate the designed optical couplings in terms of optical efficiency and durability.

METHODS Two optical couplings (C1 and C2) were designed, built, and compared. C1 consists of a stationary probe that is tightly aligned with a rotating instrument tip, on a 0.2 mm thick bearing, with light being coupled from the stationary to the rotary part (and vice versa) by two collimating lenses. C2 is a design in which there actually is no coupling at all but in which an optical fiber (with an imaging lens of 0.25 mm at its tip) is constantly being deformed by the rotations of the rotating instrument tip. For both optical couplings the optical efficiency was measured. Wear of the bearing was investigated for C1. For C2 it was investigated whether the high-speed deformation cycles would heat the mechanism or damage the optical fiber, causing reduction of optical efficiency.

RESULTS The optical efficiency of C2 was close to 100% while C1 showed significant coupling losses. Wear of C1 is still under investigation, the results being expected around July 2012. C2 showed no significant heating of the mechanism and no fiber damage even after tens of thousands of rotations.

CONCLUSION The simplicity, optical efficiency, and durability of C2 clearly makes this concept the optical coupling of choice for instruments where this mechanism can be applied.