Clinical applicability of robot-guided contact-free laser osteotomy in cranio-maxillo-facial surgery: in-vitro simulation and in-vivo surgery in minipig mandibles

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Laser was being used in medicine soon after its invention. However, it has been possible to excise hard tissue with lasers only recently, and the Er:YAG laser is now established in the treatment of damaged teeth. Recently experimental studies have investigated its use in bone surgery, where its major advantages are freedom of cutting geometry and precision. However, these advantages become apparent only when the system is used with robotic guidance. The main challenge is ergonomic integration of the laser and the robot, otherwise the surgeon's space in the operating theatre is obstructed during the procedure. Here we present our first experiences with an integrated, miniaturised laser system guided by a surgical robot. An Er:YAG laser source and the corresponding optical system were integrated into a composite casing that was mounted on a surgical robotic arm. The robot-guided laser system was connected to a computer-assisted preoperative planning and intraoperative navigation system, and the laser osteotome was used in an operating theatre to create defects of different shapes in the mandibles of 6 minipigs. Similar defects were created on the opposite side with a piezoelectric (PZE) osteotome and a conventional drill guided by a surgeon. The performance was analysed from the points of view of the workflow, ergonomics, ease of use, and safety features. The integrated robot-guided laser osteotome can be ergonomically used in the operating theatre. The computer-assisted and robot-guided laser osteotome is likely to be suitable for clinical use for ostectomies that require considerable accuracy and individual shape.
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