Respiratory Motion Compensation for the Robot-guided Laser Osteotome

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PURPOSE: The use of a robot-guided laser osteotome for median sternotomy is impeded by prohibiting cutting inaccuracies due to respiration-induced motions of the thorax. With this paper, we advance today's methodologies in sternotomy procedures by introducing the concept of novel 3D functional cuts and a respiratory motion compensation algorithm for the computer-assisted and robot-guided laser osteotome, CARLOő. METHODS: We present a trajectory planning algorithm for performing 3D functional cuts at a constant cutting velocity. In addition, we propose the use of Gaussian process (GP) prediction in order to anticipate the sternum's pose providing enough time for the CARLOő device to adjust the position of the laser source. RESULTS: We analysed the performance of the proposed algorithms on a computer-based simulation framework of the CARLOő device. The median position error of the laser focal point has shown to be reduced from 0.22 mm without GP prediction to 0.19 mm with GP prediction. CONCLUSION: The encouraging simulation results support the proposed respiratory motion compensation algorithm for robot-guided laser osteotomy on the thorax. Successful compensation of the respiration-induced motion of the thorax opens doors for robot-guided laser sternotomy and the related novel cutting patterns. These functional cuts hold great potential to significantly improve postoperative sternal stability and therefore reduce pain and recovery time for the patient. By enabling functional cuts, we approach an important threshold moment in the history of osteotomy, creating innovative opportunities which reach far beyond the classic linear cutting patterns.
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