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Robot Guided Water Jet Cutting to Assist Osteotomies of Human Bones*

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***Abstract*— Displacement osteotomy is an operative method for load relieving of pre-damaged joints through the correction of skeletally-based abnormal displacements of leg axes. We present an experimental operating room set-up to demonstrate the applicability of a robot guided water jet osteotomy for human tibial bones. We show that smooth, circular shaped cut surfaces can be obtained with this technology that allow for an easy and precise correction of the leg axis.**

I. Introduction

Displacement osteotomy is an operative technique for correcting mal-aligned leg axes in order to relieve the load in adjacent joints. Conventional techniques using oscillating saws are limited to straight cuts and only allow wedge type corrections which are usually associated with problems such as a change in length of the leg.

The optimal shape for a cut path would be circular using the so-called focal dome osteotomy which maximizes the bone contact in the cut area and avoids length changes. In clinical practice however, this type of osteotomy is only rarely applied due to manual impracticability. Hence, the introduction of new technologies to support this type of osteotomy is desirable.

II. Material and Methods

An experimental operating room set-up was developed utilizing a Stäubli RX 90 robot to guide a water jet cutting head (cf. Figure 1). The planning of the cutting process takes place on a reconstructed surface model of the bone acquired from an intraoperative 3D X-ray scan. In the current version of our self-developed software, the user plans the cutting path manually by placing a segment of a circle on the screen such that it matches the anatomy of the bone. The software subsequently generates a series of set-points on the bone surface which are then used to control the robot.

As the water jet would also cut through all objects on the back side of the bone, the water jet energy has to be dissipated to avoid damage to any human tissues. In order to achieve this, a jet absorber was developed and manufactured by our group. This jet absorber has to be placed on the back side of the bone and can at the same time be used to suck the major amount of water out of the operating field. The cutting head, the jet absorber, and the bone are equipped with reference bases of an optical tracking system (cf. Figure 1). This way safety is ensured, as the water jet will only be activated if the cutting head is placed correctly with respect to the bone and to the absorber so that the water jet hits the absorber surface on all set-points of the planned path.

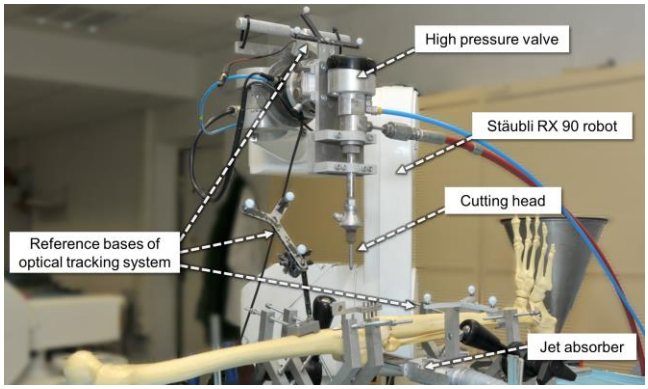

Figure 1. The robot guided water jet osteotomy set-up with a plastic bone.

We tested the set-up and the complete procedure including planning and robot guided water jet cutting in three operations using two alcohol conserved human cadavers.

III. Results and Conclusion

All performed osteotomies could be finished without complications and achieved the desired circular cutting shape with a smooth cut surface allowing for an easy and smooth rotational alignment of the leg.

We conclude that robot guided water jet cutting of human bones is a new and promising technology which has the potential to improve the quality of osteotomies and furthermore support the healing process. However, to be applicable in clinical practice, further research and development is necessary. This includes further miniaturization of the jet absorber and optimization of the water suction device as well as the computer assisted planning procedure based on biomechanical parameters. A more detailed description of the system and the experiments has been published in [1].

References

[1] D. Zaremba, R. Westphal, E. Suero, C. Krettek, F. M. Wahl, Fr.-W. Bach, T. Hassel, "Robot-assisted displacement osteotomy by the abrasive waterjet – concept and technical realization" presented at the WJTA-IMCA Conference and Expo, Houston, September 9-11, 2013.

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