Endoscopic Single-shot 3D Reconstruction of Oral Cavity

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***Abstract*— We present a stereo-endoscopic framework that allows real-time capable image-based measurements of anatomical structures. A 3D endoscope is used to reconstruct the oral cavity to measure orofacial cleft of five pediatric patients.**

I. INTRODUCTION

Orofacial cleft is a congenital birth defect. It often comes with several physical and aesthetic problems for the patient including breathing difficulties, speech problems, food intake, dental malposition or negative influence of middle ear ventilation. To overcome these problems, it is necessary to perform a surgery. For a cleft palate intervention, an obturator plate is needed to cover the cleft. This plate is created by a silicone impression while the patient is under anesthesia. It is desirable to avoid such interventions by replacing the impression by an optical measurement to reduce surgical risk and improve patient's well-being.

II. METHODS

For a correct and robust 3D reconstruction, a calibration of the stereoscopic system is crucial to get a real world representation of the surgical scene and the underlying optical system. The calibration method follows a model-based approach using synthesized images and applying an image registration via gradient-descent. For an overview of calibrating medical imaging systems, we refer to [1,2]. A successful calibrated stereo system allows performing image-based measurements. Therefore, a real-time capable image processing pipeline is applied, which has been used for simple point-to-point distance measurements inside the tympanic cavity [3]. This measurement tool consists of two steps: It performs a quasi-auto calibration by a scene dependent rectification of image pairs and a highly parallelized sub-pixel dense disparity estimation, reducing the correspondence problem to a 1D-search. This results in a fast and robust stereo estimation of correspondences to calculate the related metric depth information. This depth information allows an accurate measurement of the captured anatomical structure [4]. For this work, five patients with lip/cleft palate are evaluated. The cleft size is measured using the point-to-point measurement tool. In addition, the oral cavity including the relevant cleft palate is 3D reconstructed.

III. RESULTS

For all five patients, the oral cavity including lip cleft and palate cleft could be reconstructed. Fig. 1 shows reconstruction results of the oral cavity for two patients and the survey of the cleft palate in two directions. Besides the successful reconstruction, we can also perform valuable image-based measurements of the cleft palate to determine its size. For further validation of our results, the 3D endoscope has been validated using specimens with known dimensions. Empirical specimen evaluation give accuracies of approx. 1/10mm for several hundred point-to-point measurements.

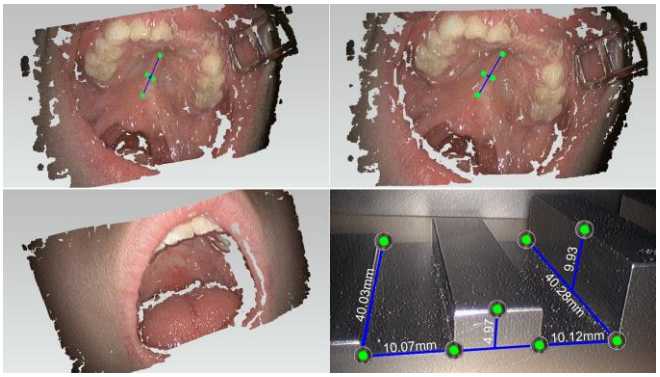

Figure 1. Two single-shot 3D reconstructions results of oral cavity. Upper row: point-to-point distance measurements of cleft: 4.3mm/22.3mm. Bottom left: several ground-truth measurements on specimen.

IV. DISCUSSION & CONCLUSION

Based on this true-scale anatomy representation, the surgeon will be able to measure the exact size and extract the anatomy without the need of a silicone impression and several fitting iterations. From this approach, three main benefits arise: (1) the risk of complications caused by harmful tissue contact is reduced, (2) an exact patient anatomy is received in near real-time and (3) anesthesia can be avoided. As next steps, we focus on the following two issues: (1) comparing our reconstruction results to existing obturator plates (2) planning an easy-to-use measurement toolbox for the surgeon.

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