Facial esthetics engineering: a concept for integration of precision and beauty in computer assisted surgery

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Abstract:

Towards the last years we can observe a strong trend towards preoperative planning and integration of rapid prototyping methods into computer assisted surgery workflows. In this lecture we summarize the current state of development in the field of interactive teleplanning and present recent clinical results of navigation guided insertion of individualized 3D facial implants, manufactured according to soft tissue simulations. Furthermore, we recommend to include the patient's hairline respectively the biomechanics of the haired skull in planning algorithms in order to consider the impact of hairline design for the patient's facial esthetics.

Keywords: Teleplanning, rapid prototyping, esthetics

1 Problem

Rapid protoyping has been gaining in significance within the frame of computer assisted (tele-)planning and image guided surgery workflows. Currently, the most prominent challenges address the fusion of soft- and hardtissue properties with abstract esthetical criteria, also comprising the patients' hairline.

2 Material and Methods

Established augmented reality and image guided surgery methods for preoperative planning as well as for intraoperative navigation are merged with rapid prototyping procedures. 3D photogrammetry adds a quantitative measure in postoperative evaluations when merged with the corresponding preoperative soft tissue prediction. For this purpose the postoperative patient's face is scanned using a 3D photogrammetry system (Dimensional Imaging Inc., Glasgow, Scotland, UK) two month after surgery. Simulation error is quantified by calculation of the Hausdorff distance using MESH 1.13 (open source software; Reference: Aspert N, Santa-Cruz D, Ebrahimi T: MESH: Measuring Error between Surfaces using the Hausdorff distance. Proceedings of the IEEE International Conference in Multimedia and Expo 2002 (ICME) 1:705–708, 2002.)

3 Results

The navigated insertion of customized facial implants could already be successfully established in clinical routine, providing highly satisfying esthetical and functional outcome. A preoperative plan can be exactly transferred to the patients and – due to preoperative soft tissue simulations – enables a completely natural look. In our first clinical application the quantitative evaluation of correspondence between preoperative simulation (i.e. soft-tissue prediction) and postoperative photogrammetric imaging revealed high correspondence at facial regions covering the implants.

4 Discussion

A major challenge for the near future will be the full integration of all functional and esthetic factors in cranio- maxillofacial surgery in one comprehensive computer based plan, even if the surgical interventions are scheduled at different times and hospitals. This approach requires a sophisticated interactive platform, enabling the fusion of the precision from engineering with the abstract term "esthetics". Therefore we call this concept "facial esthetics engineering". It comprises also the future optimization of hair transplant surgery, which is – in fact – a "missing brick" in currently

available medical soft tissue simulations, regardless of the specific clinical context. The patients' hair is usually not at all considered or visualized (neither the scalp hair nor the eyebrows or eyelashes) in computer assisted cranio-maxillofacial surgery. Our future research and development activities will focus on this topic, aiming at a full integration of (semi)automatic trichogrammetry and trichodensitometry into computer aided treatment workflows in order to improve "expressiveness" of simulations especially in the facial region. Further progress can be expected from analyzes of biomechanical properties of the haired scalp, e.g. for treatment planning in burn victims when applying expander or extender techniques: Once the mechanical behavior of the skin is known exactly, expanding or extending the haired region of the scalp followed by scalp reduction in the bold areas could be simulated and planned in order to optimize hair restoration surgery.

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